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A FAMOUS RUSSIAN ENCYCLOPAEDIA OF ASTRONAUTICS—1

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In 1949 M. Esnault-Pelterie, a great pioneer of space-flight and one of the Society's Honorary Fellows, presented the B.I.S. with a number of early books on astronautics. Amongst these was one of great rarity, Professor N. A. Rynin's work, *Mezhplanetnye Soobshcheniya* (Interplanetary Communications), published over the period 1928–32 in nine books. While the set presented to the Society is not complete (the first book is missing), from enquiries I have made it appears to be unequalled in this country, and possibly in any country outside the U.S.S.R. Indeed, the only other copies I have been able to locate are two of the books in the library of the Royal Aeronautical Society. While it has proved to be impossible to obtain information about any copies which may exist in the U.S.S.R., it is natural to assume that at least some of the volumes will have been deposited in the libraries of Russian universities or the Academy of Sciences.

In view of these facts and because the work is written entirely in Russian, which must be incomprehensible to most members, the following account of its contents has been prepared. As far as is known, this is the first time such an account has been published in English.

Little is known about the author, Professor Nikolai Alekseevich Rynin, except that he lived in Leningrad, and was therefore possibly on the staff of Leningrad University. He was one of the leaders of the pre-war Russian rocket society, Gruppa Izucheniya Reaktivnogo Dvizheniya. Since he was publishing works on descriptive geometry and optics in 1907–8, he must be at least 65–70 years old if still alive today.

From a comparison of the various volumes, it is evident that Rynin's conception of the work changed more than once as it progressed. The final scheme given in the last book has been accepted as definitive, and is used as such in this article. Particulars of the changes which Rynin made, together with other bibliographical details, will be given in an Appendix, since they may not be of interest to most members, although worth putting on record.

In Rynin's final scheme the nine books are grouped into three "volumes," each containing three "issues" or "numbers" These are as follows:—

VOLUME I.

I. *Mechty, Legendy i Pervyi Fantazii* (Dreams, Legends and First Fantasies).

II. *Kosmicheskie Korabli: Mezhplanetnye Soobschcheniya v Fantaziyakh Romanistov* (Cosmic Ships: Interplanetary Communications in the Fantasies of Novelists).

III. *Luchistaya Energiya v Fantaziyakh Romanistov i v Proektakh Uchenykh* (Radiant Energy in the Fantasies of the Novelists and in Projects of Scientists).

VOLUME II.

IV. *Rakety i Dvigateli Pryamoi Reaktsii: Istoriya, Teoriya i Tekhnika* (Rockets and Direct Reaction Motors: History, Theory and Practice).

V. *Teoriya Reaktivnogo Dvizheniya* (Theory of Reactive Motion).

VI. *Superaviatsiya i Superartilleriya* (Superaviation and Superartillery).

VOLUME III.

VII. *Russkii Izobretatel' i Uchenyi Konstantin Eduardovich Tsiolkovskii: Ego Biografiya, Raboty i Rakety* (Russian Inventor and Scientist Konstantin Eduardovich Tsiolkovskii: His Biography, Works and Rockets).

VIII. *Teoriya Kosmicheskogo Poleta* (Theory of Cosmic Flight).

IX. *Astronavigatsiya: Letopis' i Bibliografiya* (Astronavigation: Chronicle and Bibliography).

Each of these books is reviewed below in turn, under the headings of the "short titles" by which the books are known.

I. *Dreams, Legends and First Fantasies.*

As this book is the one missing from the Society's set, it is not possible to say much about it. The title gives some indication of the contents, and further information is given in the introduction to the following book, which states that the author has ". . . already written of man's elementary ideas, beginning with the most ancient times, of penetrating to the celestial worlds; these ideas were naive, many even absurd from the modern point of view, but their appearance was explained by the level of previous knowledge and man's outlook on nature." From the contents list (given at the end of the ninth book), we learn that the Chapter headings are: 1. Dreams of conquest of heavenly space. 2. Legends and flights on birds. 3. Flights of Cyrano-de-Bergerac to the Moon and to the Sun. 4. Flights on horses. 5. Flights on Spirits. 6. Flights in the Bible and in occult works. 7. Flights on heavenly bodies. 8. Flights on aeronautical devices. 9. Technical projects. It is perhaps fortunate that of the nine books it is this one which is missing, dealing as it does with material of only literary and historical interest.

II. *Cosmic Ships.*

Here again Rynin is concerned with works of fiction, but this time it is with the science fiction of Verne and others rather than the myths of the ancient world and middle ages. Yet although the emphasis has shifted from the use of animals and supernatural agencies to projects of a technical nature, most of these seem almost equally quaint to us to-day. Rynin outlines and critically discusses the ideas involved in each story, classifying them according to the nature of the means employed.

Before this century, the potentialities of the rocket were little understood, and one of the more popular methods of propulsion was the gun. Perhaps the most famous example of this is the one described in Jules Verne's *From the Earth to the Moon* and its sequel *Round the Moon*, but in a lesser-known story—*Begum's Five Hundred Millions*—Verne uses a 300-ton gun with a bore 1·5 m. in diameter firing missiles consisting of a hundred smaller guns nestling telescopically within one another. The final missile was intended to fall on another town, but owing to an error in the calculations, attained a velocity of 10,000 metres sec. and became an artificial satellite. The parallel with to-day's projects for orbital step-rockets will be as obvious as the inadequacy of the means employed in Verne's story. Other space-guns mentioned by Rynin are from the works of Max Valier, Faure and Graffigny (their tale "Extraordinary Adventures of a Russian Savant," 1899, describes a most peculiarly-shaped projectile, fitted up inside with even a glass-fronted bookcase and a chandelier, which is fired from the crater of the volcano Cotopaxi to the Moon). H. G. Wells (*The War of the Worlds*), F. A. Radley (another Englishman, and again a novel about a trip from Mars to the Earth, *Green Machine*), the Russian, G. Zhulavskii (*On the Silver Globe*, 1911), Tsiolkovskii, and Antonio de Stefano. An American project of 1924 envisaged a gun with a vertical barrel 5·5 km. in length kept erect by guy-ropes! It is stated that in Germany a man called Leinert was shot from a gun to a height of about 25 metres, a record no doubt since exceeded, but there are certainly much easier ways of attaining such heights.

After guns there are even more unlikely methods of propulsion. H. de Graffigny devised several types of interplanetary catapults and centrifugal machines. In a French project of 1927 a glorified railway carriage travels in an evacuated tunnel in a circular path 20 km. in diameter until it attains escape velocity. Tales dealing with anti-gravity or "repulsive (or minus) matter" were written by Alexandre Dumas (*Travel to the Moon*, 1865), A. Bogdanov (*Red Star*, 1908), H. G. Wells (*First Men in the Moon*, 1901), Lasswitz (*Auf Zwei Planeten*, 1897), Fezand'e (*The Mysterious Invention of Doctor Khekensou*, 1926), N. I. Mukhanov (*Blazing Chasms*, 1924), but as Ya. I. Perel'man (another Russian who wrote prolifically on interplanetary travel), pointed out, even if such substances could exist there would be objection to them both on account of energy principles and the slowness of travel. Spaceships propelled by the pressure of light rays are not neglected: first, there is a ship conceived by Faure and Graffigny which can only be described as resembling a model of Saturn on a pedestal. Measuring 250 m. by 50 m., it was supposed to be made of

selenium—rather an exotic material of construction, even for science fiction spaceships. On approaching Venus, the ship came to pieces, the "rings" acting as a parachute. Then in 1913, B. Krasnogorskii wrote a novel describing a trip to the Moon in a cabin supported on gimbals at the centre of a 35 m. diameter mirror, balloons being used to raise the vessel through the Earth's atmosphere.

Rather less attention is given to the use of radiant energy as a means of propulsion. If it ever becomes possible to transmit energy efficiently from generator to motor across space in the form of beamed radiation, space travel will be much nearer realization. Although there is nothing inherently impossible in this idea, it is difficult at the present time to see how it might be utilized in practice, and one cannot help thinking that what is required is a discovery (like that of magnetic induction by Faraday) rather than merely an invention. Authors mentioned by Rynin as employing radiant or solar energy include V. I. Kryzhanovskii, Burroughs, G. Arel'skii, V. Goncharov, Oberth, and others. Kryzhanovskii also wrote about "electric" spaceships, as did L. B. Afanas'ev, Paul Thine, and John Jacob Estor (whose ship employed a hypothetical substance named "apergy," which could increase or reduce the attraction of a planet).

Radio waves, as distinct from other forms of radiant energy, are given a chapter to themselves. Rynin himself wrote a novel utilizing this method (*In the Aerial Ocean*, 1924), in which the principal character was, surprisingly enough, a Japanese engineer named Yamato. Others writing on similar lines were Aleksei Tolstoi, A. Yarosalvskii, S. Mihaelis (a Dane), etc. Novels on the transmissions of material objects by radio are also mentioned, but perhaps we would be straying too far into the forest of fantasy if we were to consider these.

Yet fantasy may one day become fact. Many of the younger members of the B.I.S. will have grown up in a world in which the existence of the atom bomb is unfortunately only too apparent. Older members, whether or not they remember the announcement in 1939 of Meitner and Frisch's discovery of nuclear fission, will no doubt recall that before World War II the idea of releasing atomic energy was regarded as fantastic by many scientists who should have known better. In these days of atomic submarines and aeroplanes, few scientists would consider an atomic rocket motor to be fantastic, although obviously much development work would have to be done before one could be built. Rynin describes several atomic rockets or spaceships featured in novels of the nineteenth-twenties by V. Goncharov, the British writers Wignal and Knox, and others. Seven pages are devoted to the projects of an Austrian, Franz. A. Ulinski, who even took out a patent for an interplanetary ship; morphologically, his ships were in the ringed-sphere or "Saturn" style. The original father of the atomic rocket seems to have been Esnault-Pelterie (1913).

In Chapter IX we meet more conventional spaceships, powered by rocket motors, and usually cigar-shaped, though Aleksei Tolstoi is represented by an egg-shaped vessel, and the Americans Arthur Train and John Wood by an intriguing ship which can only be described as a flying doughnut with a tripod on top. These authors were evidently advocates of forward drive, for the motor was mounted on top of the tripod, the exhaust products passing through the hole in the "doughnut." Strictly speaking, this belongs in the previous chapter,

since the motive power is the decomposition of uranium. One or two projects involved the use of rocket aeroplanes.

The final chapter is a real tonic to all except intending space-crews or small children about to depart to bed. In word and picture it tells of some of the inhabitants of the other planets, Sun, interplanetary space, etc., that have been described by novelists or literary liars. Many of these fictitious inhabitants are mere derivatives of the human form: they are provided with wings, tails, webbed feet, trunks (or probosci), antennae, enlarged brains, spines, or other appendages. Others are more "animal" in nature, if that term may be applied to them.

The variety of species appears to be greatest on the Moon, where, according to Baron Munchausen, the inhabitants fly around on the backs of three-headed vultures. According to Golberg (1741) there are two charming humanish types on Mercury: a kind of elongated pineapple with legs and head, and men with violin strings running from neck to belly and played with a bow. Wells's Martians are no doubt well known to all members. Jupiter is shown to be populated with giant insects, and Saturn with dinosaurs and butterfly men. The most incredible statement is from *Celestial Scenery* by Thomas Dick (1837). He gave the number of inhabitants on each body (681,184,000,000,000 on the Sun, 8,141,963,826,000 on Saturn's rings, etc., with a total of 703,079,774,404,000 in the Solar System). It was a great disappointment to learn that these figures were arrived at not by astronomical observation or even the exercising of extra-sensory perception, but merely by scaling-up from the then English population figure of 280 persons per square mile.

Before leaving this volume, it is of interest to mention the advertisements found on the cover. They are evidence that science fiction was quite popular in Russia about 1930. Apart from translations of novels by Wells and others, and books by Russian authors, there are particulars of back issues of a Russian magazine, *Mir Priklyuchenii* (World of Adventure) which had evidently been published for several years. The scanty information that is available to-day suggests that this interest is still maintained.

III. *Radiant Energy.*

This volume is concerned with projects, fantastic or otherwise, for signalling or telecommunication across space, or for related purposes. The first chapter can only be read with nostalgia, dealing, as it does, with "rays" mentioned in novels. To-day, the ray is out of fashion with the public, being relegated to junior's spaceman outfit (and even then, as likely as not, it is called not a ray but a sonic beam). Even flying-saucers are rarely credited with possessing them. Their place has been taken, one suspects, by nuclear energy. But before World War II "rays" were very popular, and this may well be linked with the experimental work then being carried out on radio, television and radar.

Naturally, Rynin begins with Wells's heat ray from *The War of the Worlds*. Then follows the death ray of the German, Hans Dominik (a story set in 1955) a more useful ray employed to construct the Martian canals (Gernsberg), ultra-sonics, infra-red, psychic rays (*Master of the World*, by A. Belaev), anti-aircraft rays, electric rays, etc.

From literature to more practical matters, namely the experiments carried out about 1924 by H. Grindell Matthews, an Englishman, to develop such a "death ray." These experiments were successful in that mice could be killed and small quantities of gunpowder exploded, but the fact that such rays were not used in World War II is sufficient evidence that no greater success resulted. A similar partial success was obtained in experiments of the Westinghouse Electric Co. to transmit electrical energy by radio waves. This can be done, but is not a very efficient method (of course, efficiency is not the only consideration in deciding whether a process shall be used; people living near radio stations have from time to time been prosecuted for stealing electricity from the emitted radiation by using it to energise their domestic lighting circuits). Rynin then goes on to consider cosmic rays and radiation emitted by the Sun; this leads naturally to a discussion of conditions in interplanetary space, which is followed by reports of a miscellany of "ray" experiments.

Chapters 3 and 4, dealing with interplanetary communication methods mentioned in fiction and more serious works respectively, are of more interest to us, although this is not one of the main problems of astronautics. The simplest methods are optical ones. Since radio is a comparatively recent invention, optical methods were the only ones available to the heroes of what might be termed "classical science fiction." A large number of references to the use of telescopes for this purpose have been brought together here; perhaps we need only direct our attention to one of these, a project of Noordung. This was a space-station consisting of three parts connected by cables; one being an observatory, one a solar power plant, and the third the main station (termed here an inhabited wheel).

The other popular optical method is the sending of messages by means of searchlights or other devices. Since the messages were usually supposed to be addressed to any intelligent beings that might exist on other planets, they consisted of large-scale illuminations in the form of geometrical figures (*e.g.* that for Pythagoras' theorem), cartoons of the human figure, etc. However, one could well imagine civilized communities of rational beings existing to whom both Pythagoras' theorem, and our human shape were unintelligible.

While radio messages would probably be even more incomprehensible, even if these fictitious beings possessed means of detecting them, it is interesting to note that in a 1927 novel G. Arel'skii described a hypothetical radiotelescope and televisor. While bearing no relation to those in actual use to-day, this is a pointer to the advances that have taken place over over the last twenty years. The use of television is discussed at length, but that is accepted as a matter of course to-day. Indeed, as far as science fiction is concerned, having realized that a spaceship would not have row upon row of gleaming portholes, some authors and artists of to-day seem to have gone to the other extreme, providing their ships with several television cameras, but not a single window—which may possibly indicate a deep faith in the reliability of electronic equipment.

Some members will recall that in the 1948 Halley lecture at Oxford, Professor Fritz Zwicky suggested that ultimately man might set about reconstructing not merely the Earth, but also the rest of the Universe. This proposal was startling enough, but Professor Zwicky was by no means the first to make it. In the

fifth chapter of *Radiant Energy*, Rynin outlines over thirty accounts of feats such as changing the motion of the Earth, planets or comets. Some of these are taken from early science fiction, others from more ancient, if not more venerable sources, *e.g.* Milton's *Paradise Lost*.

But after this brief glimpse of the bright and glorious, but far-off future that may one day be mankind's, we have to return to the more immediate future, which is rather more gloomy. In the final chapter, "When Will Man Fly to the Planets?" Rynin explains that interplanetary travel will become a necessity within two or three centuries. He does this by producing masses of statistics (and predicted statistics) on the Earth's population and energy resources. The population/time curve is almost a rectangular hyperbola asymptotic at about 2310 A.D.; the energy resources are, of course, strictly limited, even considering animal, tidal, and solar power. Rynin points out there are other possible sources of power, such as nuclear energy or the internal heat of the Earth, and to-day we are seeing the harnessing of nuclear energy. Yet this does not detract from Rynin's main conclusions; it merely affects the values of the figures, which are in any case hypothetical. Many authorities are to-day emphasizing the dangers of a continued increase in the world's population. These dangers are usually expressed in terms of a shortage of food, but that is not the real problem. Research should enable us to develop a wide variety of synthetic foods within a few decades. There might be opposition to these among more sophisticated people at first, but eventually they would be accepted as the semi-synthetic margarine has been. No, the real problem is that of providing the energy to produce these synthetic foods and to run our other industrial processes. Still this may be a problem that mankind may never have to face. There are ways of limiting population, and there is also unfortunately the dread possibility that the Earth's population may be drastically reduced. Indeed, this possibility is foreshadowed in a now-ominous paragraph from the final section of this volume (a section entitled *End of the World*, and headed by a quotation from the *Apocalypse*, Chapter VI, vv. 12–14):—

> "2. *Atomic Conflagration*. This theme was developed by Hans Dominik in his novel *The Legacy of the Uranides*. On one of the islands of the Pacific ocean, decomposition of atoms begins and the temperature increases abnormally. . . ."

Coming events cast their shadows before.

IV. *Rockets*.

The first three volumes dealt in the main with what one might term the "literary" side of astronautics; we now come to volumes of more technical interest. This one is concerned with the theory of rocket flight and the results of rocket experiments.

To illustrate the principle of reactive motion, Rynin mentions the effect of a hole made in the wall of a vessel subjected to internal gaseous pressure and gives examples of reactive motion in nature (the cuttlefish, seed-pods), in certain toys, and in simple experiments. Incidentally, the many line-drawings

in this and subsequent volumes are of high quality and well-produced, but the half-tone illustrations are not quite so well printed.

Chapter II gives a concise history of the development of the rocket. Rynin suggests that it originated around 3000 B.C. in China; this is over forty centuries before the usually accepted date, but is not inconceivable. The powder rocket is after all a comparatively simple device. After reviewing many of the types of powder rocket which were designed at various times up to 1916, Rynin mentions the projects for liquid-fuelled spaceships of Oberth, Tsiolkovskii, Valier and others (detailed discussion is left until later), and the experiments carried out in 1900–1912 by Alfred Maul. In this case, the rockets were used to obtain photographs of the Earth's surface, but the highest altitude reached was only about 800 metres.

The next chapter is also historical, but covers rather a wide field, and in much more detail. It is concerned with reactive motion in general, from Hero's aeolipile onwards. Over the last two centuries, many suggestions applying reactive motion to aeronautics were advanced. Since these have been discussed at length in books such as Ley's *Rockets, Missiles and Space Travel*, there is no need to describe them all in detail here, but it will not be out of place to refer to one or two of the more noteworthy, such as Molinari's reactive aerostat (1831: a balloon fitted with rocket propulsion), a reactive helicopter (1860: two upwardly-directed propellers, with steam ejected from the blades), N. Sokovnin's reactive airship, and Otto Hutzler's projectile rocket (Kais. Pat. 2917/1878: really a kind of step-shell). An ingenious, but presumably not successful, invention of August K. van-de-Kerchove and Theodore Snyerrs of Brussels (1881) was intended to propel various vehicles. Water was electrolysed and the hydrogen and oxygen produced were then mixed and burnt in a combustion chamber with convergent-divergent nozzle. The obvious drawback to this is that either one has to cart a large number of electrolytic cells about on the vehicle (together with a source of electric power not less than that finally available from the H_2 and O_2) or the gases are going to be consumed at a much greater rate than they are produced. Leaving aside the generator section, the propulsion part of this invention seems remarkably prophetic.

Next, eight pages are devoted to the unfortunate story of the revolutionary, Nikolai Ivanovich Kibal'chich, who was executed for complicity in the assassination of Tsar Alexander II, and left a plan for a (rather impracticable) rocket aeroplane behind in the police archives, where it was found in 1917. Kibal'chich was executed on April 3, 1881; the closing years of the nineteenth-century saw many other such projects proposed. Indeed it is quite apparent that while the current public interest in space-travel may be a comparatively recent development, technologists and inventors have shown a lively and continued interest in rocket propulsion for many decades. Men such as René Lorin (1910–1912), Gorkhov, and Esnault-Pelterie prepared designs of rocket aeroplanes, which in appearance at least would be quite at home in the world of to-day. No suitable power plant had yet been developed at that time, however. The Italian engineer Gussalli designed and carried out experiments on a gas turbine in 1923.

But not all the projects or experiments were concerned with flying, let alone astronautics; rocket railway trains and rocket cars were not neglected. The

experiments of Opel, Sander and Valier will be known to B.I.S. members who have attended the society's film shows.

This chapter ends with a brief account of more important experiments: those of Winkler (founder of the VfR), Hoefft (founder of the Austrian Society for High-Altitude Exploration) and Lippisch. These experiments were to investigate the performance and characteristics of small rockets.

Chapters IV-VII are concerned not with experiment, but with the mathematical theory of rocket motion, as developed by various workers: Chapter IV with the theories of F. Rost, Drzhevetskii and Paul Popovatz; Chapter V with the work of D. P. Ryabushinskii; Chapter VI with that of Giovanni Pegna; and Chapter VII with the theories of Antonio de Stefano. Rost considered the dynamics of a vessel provided with an orifice and containing air under constant pressure, Drzhevetskii the vertical motion of a rocket, and Popovatz the thermodynamics of the motor.

The work of Ryabushinskii is also concerned with thermodynamics. It was originally published in the *Bulletins* of the Kuchino Aerodynamic Institute (which he founded), over the period 1906–1914, and in *Revue Général de l'Aéronautique* (1925, No. 6). Rynin has reproduced these articles in full. The first is mainly concerned with a pneumatic rocket invented by General Pomortsev, and consisting of a steel cylinder closed at one end and fitted with convergent-divergent nozzle at the other. This was filled with air compressed to 100–125 atmospheres, and gasoline, ether or suitable powders were introduced to form combustible mixtures. Ryabushkinskii develops formulae for the changes in pressure and reaction as functions of time, the impulse, the range, effect of the length of the rocket on the range, etc. He states that his experiments have confirmed the theory, but that he is unable to publish the results. The theory is extended to compare the rocket with a pneumatic gun. The second paper deals with the resistance of fluids at various speeds, and with the reaction produced by the exhaust gases of a rocket. It does give the results of experiments in firimg small rockets, horizontal ranges of up to 320 metres being obtained.

Rynin has also translated Pegna's work, which first appeared in the Italian journals *L'àla d'Italia* (1926, Nos. 2 and 4), and *Rivista Aeronautica* (1926, No. 1); he also reproduces Professor Crocco's criticism of the work. This paper deals with the thermodynamics and ballistics of a rocket projectile fired from a gun, and occupies some 22 pages. Pegna considers three stages: pressure inside gun rising to maximum, constant pressure, and pressure returning to atmospheric. However, the idea of firing spaceships from guns has now been abandoned, except in fiction, so that this section is of little interest as far as astronautics is concerned, although it may be relevant in the case of small military rockets. A translation is again given in the case of de Stefano, the original paper being published in *Revista di Artiglieria e Genio* (September-October, 1926). It is also concerned with artillery rockets.

The final chapter of *Rockets* is about the rocket in interplanetary space. Rynin briefly reviews the work of Ganswindt, Tsiolkovskii, Perel'man, Rodnykh, Ulinskii, Gussali, and others. Next follows the elementary theory of rocket motion, namely the derivation of the relation between mass ratio and exhaust

velocity by integration of the momentum equation. Various projects for rocket aeroplanes proposed by Max Valier and F. A. Sander are illustrated, and Hohmann's calculations on flight in various elliptical orbits, and for various interplanetary journeys, are given in some detail. The two final items provide a strong parallel with present-day activities in the astronautical world. The first is an account of "The First World Exhibition of Interplanetary Apparatus and Machinery in Moscow." This was held from April-June, 1927, and except for the period of time during which it was open it seems to have been organized on much the same lines as the B.I.S. conversazione held in 1949, or the exhibition held at the Stuttgart Congress. The other item is a proposal for an Institute of Interplanetary Communications, with a list of the departments it should contain.

(*To be continued*)

HAS THE EARTH A SECOND MOON?

By PATRICK MOORE, F.R.A.S.

The Earth has been accompanied by its faithful Moon for as far back as geological research can take us, though it is still uncertain whether the Queen of Night ever formed part of the terrestrial globe. Modern research seems to indicate that she did not—but her association with the Earth must go back almost, if not quite, to the time of the formation of the planetary system.

Yet although our Moon is by far the largest satellite in the Solar System in relation to her primary, other planets have veritable families of satellites; Uranus has five moons, Saturn nine, Jupiter as many as twelve. Is there any chance of the Earth's being accompanied by a second satellite, so far undetected?

If a second moon exists, it is certainly very small. Deimos, the junior attendant of Mars, has a diameter of only about five miles, but we may be sure that a five-mile globe within a quarter of a million miles of us would have been found long before now. Deimos is not, of course, the dwarf of the Solar System. Quite apart from the myriads of meteors that circle the Sun, there are several known asteroids whose diameters are appreciably less. For instance, Hermes, which passed by us in 1937 at a distance of only 400,000 miles, has a diameter of less than two miles, and may be regarded either as a giant meteorite or as a minute asteroid.

The idea of a second terrestrial satellite goes back well over a century, and seems to have originated with a Frenchman named Pettit, who thought that a second body existed at a distance of about 6,000 miles above the Earth's surface, completing one revolution in 3¼ hours. The idea was used by Jules Verne in his famous novel *From the Earth to the Moon*, probably the earliest science-fiction story that is still widely read. He described it graphically from the point of view of his heroes, who had been fired off in a projectile from the mouth of the gigantic Columbiad cannon: "An enormous disk, the dimensions of which could not be estimated. . . . It looked like a small moon reflecting the light of the large one. It advanced at a prodigious speed . . . to its movement was added a movement of rotation upon itself." The second moon

was, in fact, essential to Verne's story, as it perturbed the motion of the space-ship projectile and swung it into an orbit that carried it round the Moon before falling back on to the Earth.

Of course, there was no evidence that such a body existed, but the question was taken up some years later by an eminent American astronomer, Professor W. H. Pickering, who wrote several papers on the subject between 1904 and 1922. He worked out that if the second satellite revolved at a distance of 200 miles above the Earth, and was only a foot in diameter, it should be easily visible in a 3-in. telescope (assuming that it had the same reflecting power as the Moon). At such a distance, a 10-ft. satellite would be of stellar magnitude 5, so that it would be easily visible without a telescope at all.

Pickering gave some details as to a possible search for such a satellite. "The body would move too rapidly to leave a trail on a photographic plate," he wrote. "A 3 in. to 5 in. telescope with a low-power eyepiece would be the likeliest means of finding it. It is an opportunity for the amateur."

Pickering never instituted such a search himself. He did, however, investigate the possibility of the Moon itself having a satellite—a moon of a moon! (After all, there is nothing improbable in this. The Moon is not much smaller than Mercury, which is regarded as a major planet.) He carried out a systematic search, visually and photographically, but the result was negative, and he concluded that no such sub-satellite above a few feet in diameter could exist.

It is, of course, true that a body less than a yard or so across would probably escape detection at a distance of several thousands of miles; but a larger object at a much greater distance may, conceivably, exist. Suggestions have been made that such a body revolves so as to keep permanently behind the Moon, and thus invisible. Theoretically, this is a possibility; practically, it is not—before long on the cosmical time-scale, some minor perturbation would disturb it and cause it to move away from its stable position.

Radar methods have not so far been used to search for a minor satellite, but very recently the whole question has been re-opened. A report from America states that a systematic search for tiny moonlets has been started by Clyde Tombaugh at the Lowell Observatory, Flagstaff. No-one could be better fitted for such a task; Tombaugh has already added a much more important body to the Solar System—he discovered the major planet Pluto in 1930.

Whether he will be successful or not remains to be seen. At all events, it is safe to say that any so-far undetected moonlet must be too small to rank as a proper satellite, and can be nothing more than a meteor-sized rocky particle, irregular in form and with a gravitational pull too small to be detected even by the most refined methods.

We must conclude that the Earth has only one satellite worthy of the title. However, the day will come when this will be no longer true, even if the "second moon" will be a man-made, metallic structure, rather than a rocky globe fashioned by the arts of Nature.

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ORBITS FOR AN EXTRA-TERRESTRIAL OBSERVATORY

By C. A. Cross, M.A.

SUMMARY

It is unlikely that telescopes can be built on the Earth's surface very much larger than the 200-in. Hale reflector. In a free orbit many of the constructional limitations are removed, but the structure must be shielded from solar radiation. This may be achieved by putting the telescope in an outer Lagrangian equilibrium point, with a planet between it and the Sun. In certain circumstances the Sun is then permanently eclipsed.

Not all the planets are suitable for this purpose. Venus and Earth are too dense, and only give annular eclipses. All the other planets give total eclipses, but the station beyond Mars would presumably be the most suitable.

There seems to be general agreement,[1,2,3] that the 200-in. Hale telescope represents an upper practical limit to the size of mirror which can be mounted on the Earth's surface so as to be capable of orientation in a fixed direction in space. Further large increases of aperture may possibly be obtained by fixing the mirror with respect to the surface of the Earth, and accepting a limited exposure time.[3] Alternatively the mirror may be placed in an orbit in free fall,[1,2,4] where the gravitational forces which cause distortion are eliminated. Under these conditions mirrors of an order larger than in the Hale telescope, and of incredibly flimsy construction, could be held in any desired orientation without change of figure. Moreover there would be no atmosphere between the mirror and the stars.

Apart from the immense problems of placing the equipment in an orbit, there is another difficulty with which this note is especially concerned. How is such an extra-terrestial observatory to be shielded from solar and terrestial radiation so as to provide the equivalent of night time conditions on the Earth's surface? The orbits normally considered[1] are around the Earth, and subject the observatory to full solar radiation, with perhaps short interruptions whilst the sun is eclipsed by the Earth. There is also the variable radiation from the Earth as it goes through its phases once per revolution of the observatory in its orbit. These sudden changes would have disastrous effects on the condition of the mirror, and the dimensions of the supporting structure, whilst the intensity of this radiation would certainly prevent long exposure photographs. It seems unlikely that any form of local screening could be made really effective. Even if it could the maintenance of the screens in their correct orientation would be a major problem, and unless they were held several miles away from the instrument they would blot out a large area of sky.

It is evident that the ideal orbit would place the observatory in a constant radiation environment with the sun permanently eclipsed. Such orbits are available, although they are not stable in the astronomical sense. If we situate our observatory in the equivalent of an outer Lagrangian equilibrium point, with a planet between it and the sun, then in certain circumstances the sun will be permanently and totally eclipsed by the planet.

The particular case of the restricted three-body problem which is involved in these orbits is not treated by Moulton,[5] who deals with both the less general

case in which the two massive bodies are restricted to circular motion, and the more general case where all three bodies are massive. For the sake of completeness the full derivation of the orbit equation is presented in Appendix 1. This extension from the circular orbits does not present the difficulty which is suggested in the summary,[6] and indeed equation 4 is formally identical with Clarke's equation 111, except for an extra term. This is because Clarke has assumed rotation around the centre of gravity of the primary, instead of around the centre of mass of the whole system. His equation lacks the term $1 - (x - 1)^3$.

Equation 4 shows that for a given planet the ratio of the angular diameters of the Sun and the planet is always the same when viewed from the Lagrangian equilibrium point, no matter what orbit the planet pursues around the Sun, and for all positions in that orbit. By combining the orbit equation with the equation giving the length of the cone of shadow, we obtain a relation (Equation 6) which defines the conditions under which the planet always exactly eclipses the Sun. This equation shows that the extent of the eclipse depends only on the ratios of the mass and density of the planet and Sun.

TABLE I

NUMERICAL EVALUATION EQUATIONS 4 AND 6

x	m	ρ	d
1·0	0	3·0	0
1·001	$2{\cdot}997 \times 10^{-9}$	3·006	0·000999
1·010	$2{\cdot}9694 \times 10^{-6}$	3·0604	0·0099
1·100	$2{\cdot}734 \times 10^{-3}$	3·6410	0·0909
1·200	$2{\cdot}40 \times 10^{-2}$	4·40	0·166
1·300	$6{\cdot}55 \times 10^{-2}$	5·32	0·231
1·400	$1{\cdot}52 \times 10^{-1}$	6·53	0·276
1·500	$3{\cdot}01 \times 10^{-1}$	8·14	0·333
1·600	$5{\cdot}55 \times 10^{-1}$	10·5	0·375
1·700	1·05	14·5	0·412

The Table shows how the critical density ratio ρ varies with the ratio of the mass of the planet and sun. It is very little dependent on this mass ratio in the region of planetary masses encountered in the solar system, but it rises sharply as the "planet's" mass becomes comparable with the sun's.

This dependence is worked out in Table I. As the planet approaches zero mass the limiting density for which a complete eclipse is achieved becomes three times that of the Sun. For planets of higher density than this the eclipse is annular, and for lower densities the apparent diameter of the planet is greater than that of the Sun. For more massive planets a slightly higher density becomes permissible. For a planet of Jupiter's mass the critical density is 3·6.

In the solar system the outer Lagrangian equilibrium points associated with Venus and the Earth both give orbits from which the Sun is in annular eclipse. Moreover, in the case of the Earth the disc would swing perceptibly to and fro across the Sun because of the presence of the Moon. These orbits would not be suitable for the location of an observatory.

TABLE II

VALUES OF m AND ρ FOR THE PLANETS

Planet	m	ρ	View from Third Body
Mercury	$1{\cdot}11 \times 10^{-7}$	2·64	Total eclipse
Venus	$2{\cdot}38 \times 10^{-6}$	3·69	Annular eclipse
Earth	$3{\cdot}04 \times 10^{-6}$	3·92	Annular eclipse
Mars	$3{\cdot}24 \times 10^{-7}$	2·80	Total eclipse
Jupiter	$9{\cdot}55 \times 10^{-4}$	0·95	Total eclipse
Saturn	$2{\cdot}76 \times 10^{-4}$	0·49	Total eclipse
Uranus	$4{\cdot}37 \times 10^{-5}$	0·96	Total eclipse
Neptune	$5{\cdot}18 \times 10^{-5}$	0·94	Total eclipse
Pluto	—	—	?

This Table shows the mass and density ratios of all the major planets in the solar system.[7] It will be seen that except for Venus and the Earth all the planets give a total eclipse at the outer Lagrangian equilibrium point. For Venus and the Earth the planet densities exceed the critical ratio, and the eclipse is annular.

All the other planets (Table II) give orbits from which the Sun is permanently and totally eclipsed. Unless these positions are "meteor funnels,"[6] they offer ideal situations for the extra-terrestrial observatory.

It may be presumed that the station associated with Mars would be the preferred position, for it is the nearest to the Earth. The approach to the Mercurian station would be an uncomfortably warm journey, and the zodiacal light might be troublesome at this distance from the Sun. Occupation of this site would, however, allow of permanent observation of the corona under ideal conditions.

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APPENDIX I

PROBLEM:

Consider a sun with a satellite revolving around it in an elliptical orbit. Determine (*a*) whether there is another orbit outside this one in which an infinitesmal third body may revolve so that the sun and planet are always in line with it; (*b*) the conditions that must be fulfilled for the planet to eclipse the sun for an observer on the third body.

(*a*) THE EXISTENCE OF THE ORBIT.

Let us assume that there is such an orbit, which is an ellipse about the centre of mass as focus. Then if this is so Kepler's law of equal areas requires that it shall have the same eccentricity, and its apses shall coincide, with the planetary ellipse. (Otherwise the three bodies would not remain lined up.) In these circumstances the ratio of the radii vectores of the planet and the third body must also remain constant.

Without loss of generality we may consider a sun of unit mass and a planet mass m at distance r_1 at a given moment. Suppose the third body at this instant is at distance r_2.

Then the equivalent mass M_2, which when located at the centre of gravity of the system would produce the same attraction on the third body, is given by the equation

$$\frac{1}{r_2^2} + \frac{m}{(r_2 - r_1)^2} = \frac{M_2}{\left(r_2 - \frac{r_1 m}{1+m}\right)^2} \quad (2)$$

But we have seen that the ratio of the radii vectores from the origin remains constant, and this means that r_2/r_1 is also constant, $= x$. Thus

$$\frac{1}{x^2} + \frac{m}{(x-1)^2} = \frac{M_2}{\left(x - \frac{m}{1+m}\right)^2} \quad .. \quad .. \quad .. \quad (1)$$

The attraction of the sun and planet on a third body in the orbit we have presumed therefore corresponds with the attraction of a constant single mass M_2 at the focus, and the assumption of the form of the orbit is justified.

We must now determine the value of x, which will give the third body the same period as the planet. From Kepler's third law, the cube of the semi-major axis is proportional to the equivalent mass at the focus for orbits of the same period. Thus if M_1 is the equivalent mass at the focus for the planet, and a_1 and a_2 are the semi-major axes for the planet and the third body, then

$$\frac{M_2}{M_1} = \left(\frac{a_2}{a_1}\right)^3 = \left(\frac{x - \frac{m}{1+m}}{1/(1+m)}\right)^3 \quad .. \quad .. \quad .. \quad (2)$$

But M_1 is given by

$$M_1 = \frac{1}{(1+m)^2} \quad .. \quad .. \quad .. \quad .. \quad (3)$$

Eliminating M_1 and M_2 from equations (1), (2), and (3), we obtain

$$m = \frac{(x^3 - 1)(x-1)^2}{x^2(1-(x-1)^3)} \quad .. \quad .. \quad .. \quad .. \quad (4)$$

Equation (4) gives the ratio x of the size of the two ellipses, taking the sun as origin, in terms of the ratio of the masses of the planet and sun, m.

(*b*) CONDITIONS FOR ECLIPSE.

If we take the diameter of the sun as d_1, and of the planet as d_2, then we may define the value of x, which will result in an exact eclipse as

$$\frac{x-1}{x} = \frac{d_2}{d_1} = d \quad .. \quad .. \quad .. \quad .. \quad (5)$$

but

$$\frac{m}{d^3} = \frac{\text{density of planet}}{\text{density of sun}} = \rho$$

So from equations (4) and (5) we have

$$\rho = \frac{x(x^3 - 1)}{(x-1)(1-(x-1)^3)} \quad .. \quad .. \quad .. \quad .. \quad (6)$$

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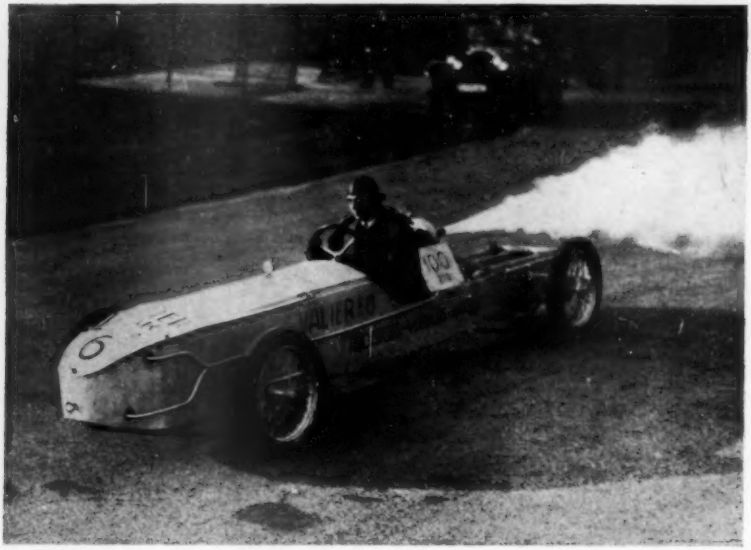


Valier driving his rocket car at the Avus, in Berlin, on December 22, 1929.
(Propelled by carbon dioxide)

Heylandt rocket car, about 1931.
(Propelled by alcohol/oxygen)

A CHAPTER IN ROCKET HISTORY

By W. H. J. Riedel

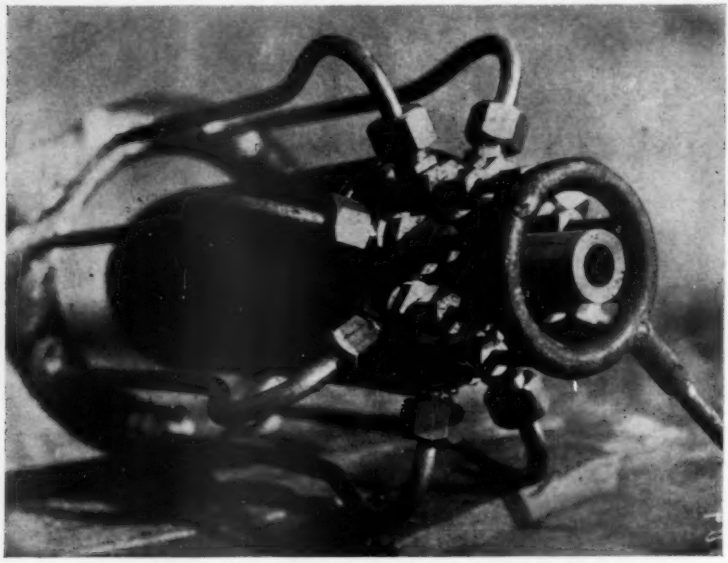
[Editorial Note:—

Twenty-five years ago, in Spring, 1928, the first rocket cars in the world hastened over Germany's racing circuits and attracted the attention of a great number of people to an appreciation of a form of propulsion, which sometime in the future, should make flight to other heavenly bodies possible. The leading figure in these pioneer tests was Max Valier, who was to give his life, much too early, on May 17, 1930, for this great idea. The rocket cars of 1928 were driven by powder rockets. However, Max Valier was also one of the first to experiment with liquid rocket propellants. One of his closest associates reports in the following on Valier's part in this development.]

In the years around 1930 there were mainly two groups interested in the practical development of liquid rockets. One group, known through the names of Hermann Oberth, Klaus Riedel, von Braun, Nebel, and others, had its working centre on the Raketenflugplatz, at Reinickendorf, in Berlin. To this group belonged the author Willy Ley, whose books report in detail the work undertaken here.

The other group, with the well-known names of Max Valier and Dr. Heylandt, worked at the factory of the firm of Heylandt at Britz, in Berlin. (The present writer came from this group and he, later, together with Dr. von Braun, collaborated on the development of liquid rockets—from the beginning to the end of the V2 development at the Heesesanstalt Peenemünde.) Max Valier, the leader of this group, was a true pioneer of rocket development. With great diligence, his whole energy and unbounded zeal, he pursued his idea. In his book *Raketenfahrt* he had announced the latest results of experiments with powder rockets made in collaboration with von Opel and Sander, but he soon realized that the use of powder rockets was limited, due to the energy content of the powder (which was lower than that of liquid propellants) and that it was time to develop liquid rockets.

It is well known that most fuels are hydrocarbons of definite compositions and that by ignition and reaction with oxygen they burn to carbon dioxide (CO_2) and water (H_2O), if dissociation is not considered, thus producing combustion gases which leave the nozzle at high velocities (1,800-2,500 m/sec.). The best oxidizer is pure oxygen. It is not practical to use it in the gaseous state since it must be stored at high pressure in strong steel bottles, with the result that the empty weight of the rocket unit would be too great. Therefore the oxygen must be used in its liquid state. Because of this Max Valier realized that he must obtain a contact with a specialist in the production and handling of liquid oxygen. Therefore he approached Dr. Heylandt, who had a factory in Berlin-Britz for the manufacture of equipment for production and transport of liquid oxygen. At the end of 1929 the negotiations were completed and Heylandt promised Valier support in the development of liquid rockets on the basis of "liquid fuels with liquid oxygen." I myself was at that time employed by the firm of Heylandt as test and development engineer on the design and development of new patents for equipment for the transport of liquid oxygen. Besides doing this work I was asked by the firm in 1929 to begin development with Max



Jet combustion chamber with eight injectors using alcohol and gaseous oxygen (1931).

Valier. Valier wished to develop a unit of high efficiency and in his opinion, the best way lay in step-by-step development. Although Valier had Heylandt's financial support, further money was to be obtained by demonstrations and lectures.

One day, at the end of 1929, the rocket car arrived in Berlin-Britz in which Max Valier had previously tested his powder rockets. It was a long wooden box with two built-in axles, a real steering-wheel and a foot-brake. The most valuable things were the tyres! While we were smiling at this vehicle Max Valier was standing by full of pride, for had he not obtained his first successes with this small improvised vehicle? It was decided to rebuild the car somewhat and to prepare a carbon-dioxide propulsion unit. This unit, of course, had nothing to do with the development of a unit with liquid propellants. According to the organizers this was a way of obtaining publicity and demonstrating, again with simple means, the principle of reaction propulsion. On December 22, 1929, the car was demonstrated before the press at the Avus track. Before the car could be started, the pressure in the six carbon-dioxide bottles was raised, whereby the carbon-dioxide was transformed from the liquid to the gas phase. A nearby restaurant provided warm water in large containers in which the steel bottles were immersed. After the pressure had reached about 100 atmospheres the bottles were put into the car, connected to the manifold, and the main valves opened. The car was ready to start. By pressing the foot-pedal the exit of the nozzle was opened and the car started to move.

In January, 1930, the actual development of combustion chambers for liquid propellants began. Basing the work on earlier experience a combustion chamber was developed with less than two months' experimental work. The chamber consisted of a standard steel tube; on one end was fixed the nozzle and on the other was the propellant injection system. The oxygen was fed into the combustion chamber from an annular space at the rear of the chamber through a number of small holes. The fuel was injected into the chamber against the oxygen gas-stream. A turbulence ring caused turbulence, thus slowing the oxygen gas-stream. The tests were carried out in the test laboratories of the firm of Heylandt. Pictures of this time show with what ignorance of possible dangers the tests were carried out.

In general the experiments were carried out as follows; after filling the tank with fuel, the tank was pressurized and by opening the fuel valve and reducing valve on the oxygen side small quantities of propellants were fed into the combustion chamber. With the flame of an ordinary blowlamp the mixture was now ignited near the nozzle exit so that a small flame developed in the combustion chamber. The propellant valves were slowly opened, thus increasing the chamber pressure and the thrust. The thrust was measured by mounting the chamber on one side of a pair of scales and counterbalancing by weights on the other side. When one thinks with what precautions present-day rocket experiments are carried out, one can only wonder at the carelessness with which the early experiments were performed.

The first time liquid oxygen was used was on March 26, 1930, and it was adopted as standard from that time on. In April, 1930, the modification of the rocket car to take the liquid propellant rocket-motor was begun. It was called "Rakn. 7." The carbon-dioxide bottles were replaced by the fuel tank, the steel nitrogen bottles for pressurizing the propellant tanks and the container for the liquid oxygen. The thrust was 20-30 kg. and the running time, depending on the quantity of propellants, was 8-10 minutes. On April 17-19, 1930, press demonstrations were successfully carried out with this car in the grounds of the firm of Heylandt. These dates are noteworthy because of their historical importance—for the first time in Germany a rocket motor using liquid propellants was shown. This time can be considered as the beginning of all the work on rocket motors using this propellant combination. Although the rocket had no practical application to wheeled vehicles, these experiments proved the possibility of burning liquid propellants to produce thrust for propulsion purposes.

During this work Valier was able to interest Deterding, the General Director of the Shell Company, in his tests. He was willing to back the development, and a rocket motor was planned for an aircraft to fly the Channel. This further development was dependent on only one condition; instead of the alcohol used earlier, Shell oil must be used. Alcohol is a fuel which can be mixed in any proportion with water, thus reducing the combustion temperature. With paraffin this is not so easily done. If water is poured into Paraffin and shaken an emulsion is formed for a short time in which the paraffin and water mix, but after a short time they separate. In order to guarantee the endurance of the chamber walls the combustion temperature must be limited. This problem was

solved by passing the paraffin through a so-called emulsion chamber before injecting it into the combustion chamber.

On May 12 some experiments were being carried out using paraffin as fuel—after earlier tests. These experiments were fatal to Valier. In the early afternoon of this day the experiments were started. The first two were successful and resulted in smooth runs. During the third test, however, shocks occurred which bent the lever transmitting the thrust to the balance. During this test the liquid oxygen tank was emptied. Because of the shocks during the last run and the time required to prepare for the next test I proposed to Valier to finish testing for the day. He was, however, so excited by the results that he intended to carry on; therefore the combustion chamber was set up again. Whereas before the nozzle diameter was 28 mm. for this test the diameter was to be 40 mm.

By 9 p.m. everything was ready. The chamber was ignited and using the normal test procedure the chamber pressure was increased to 7 atmospheres (gauge) by regulating the hand-valves for the propellants and water. This pressure had just been reached when a violent explosion occurred.

I immediately shut the propellant valves and sprang to Valier, who had collapsed. I just managed to catch him and laid him on the ground. While Arthur Rudolph, a machinist and my co-worker, looked after him, I looked for a car. When I returned 10 minutes later Max Valier was dead. A very small splinter had hit a main artery near the lungs. The probable cause of the explosion is as follows. The emulsion of paraffin and water reached the combustion chamber through a small swirl injector head. During the time when the chamber pressure was being increased part of the emulsion was burning, whilst another part remained unburnt. This unburnt part mixed with the liquid oxygen and as this latter has a low temperature a gel was produced. This mixture settled on the wall of the combustion chamber and shortly before the moment of the explosion part of the layer from the wall fell into the combustion zone and exploded.

This tragic occurrence held up the work for some time and, more important, one of the best and most respected of men had given his life for rocket development.

[*A further article on this subject by Herr Riedel appears in "Weltraumfahrt" Vol.* 3, 86-90, *July*, 1953. *Reference to it is also made in Willy Ley's "Rockets, Missiles, and Space Travel"*—ED.]

V 2

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THE "VIKING" NO. 10

The U.S. Navy "Viking" No. 10, a single-stage, high-altitude rocket, was launched successfully at White Sands proving ground, Las Cruces, N.M., May 7, 1954, and equalled the altitude record of 136 miles set previously by "Vikings" 7 and 9.

Like its forerunners, the "Viking" was designed and built by the Glen L. Martin Company for the U.S. Navy to explore altitudes previously closed to scientific research in cosmic rays, atmosphere composition, radio propagation, photography and spectroscopy.

At the point on its ascent when its fuel supply of liquid oxygen and ethyl-alcohol was exhausted, the 7½-ton, 42 ft. long rocket-vehicle was travelling at a speed of 4,000 miles per hour.

Telemetering equipment in the "Viking" relayed back to ground stations data on performance and atmospheric conditions, where it was recorded while the rocket journeyed through space.

"Viking" No 10 used a power-plant made by Reaction Motors, Inc., of Dover, N.J., delivering a thrust of 20,000 lb., i.e. of the same type as used on previous "Vikings."

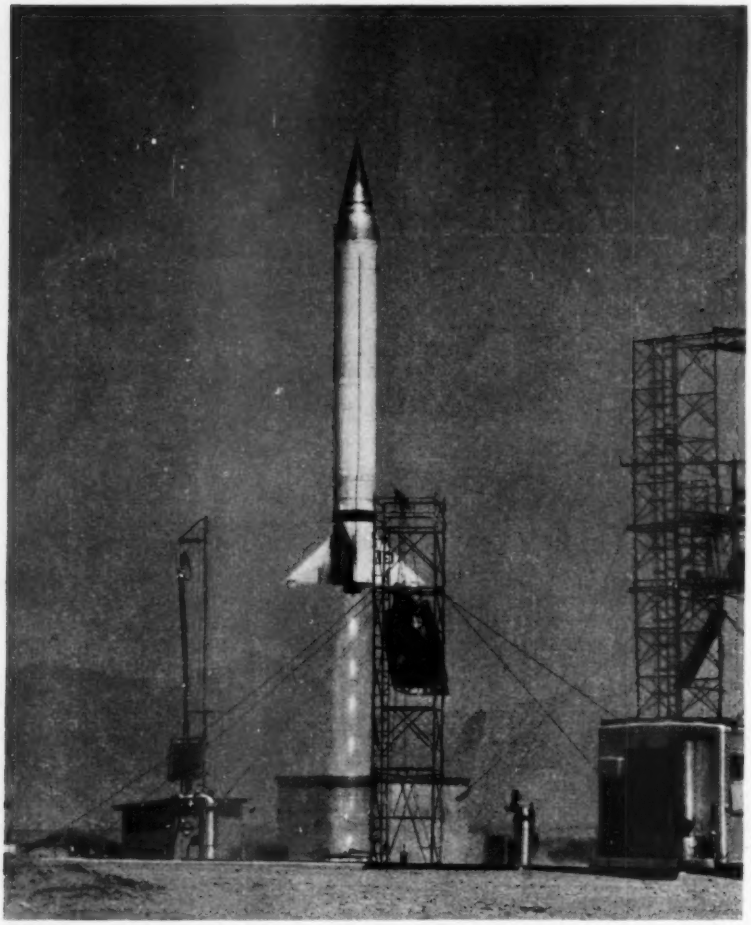
The major experiment in the rocket was designed to measure the properties of the ionosphere, the layers of charged particles surrounding the Earth, which reflect radio waves and make possible long-distance radio communication. Measurements of this type are conducted daily by agencies all over the world with transmitters and receivers located on the ground. In the "Viking" experiment, the transmitter was carried aloft and sent radio waves through the ionosphere to receivers on the ground. In this way, it is possible to get a more accurate measurement of electron density, ion density and collision frequency, which can be used to correct the daily measurements.

Other upper-air experiments in "Viking" 10 were intended to determine the ion content of the atmosphere at high altitudes, its pressure, density and wind velocities. A radio-frequency mass spectrometer carried in the nose sampled the atmosphere once every second, separated it into its charged constituents, and measured their relative abundances. Oxygen, nitrogen and argon were the gases of primary interest. The mass spectrometer was a companion to the radio experiment in exploring the ionosphere.

Emulsions prepared by the U.S. National Institutes of Health were placed within the vehicle to detect the cosmic radiation. The rocket also carried a number of cameras to determine its orientation during flight, to measure the intensity of the daylight sky illumination, and to obtain wide area photographs of the Earth's surface. Many of the instruments were devoted to measuring the performance of the rocket itself.

Physical recovery of some of the instruments—for example, the cameras—was necessary for the success of the experiments. To recover these instruments, the nose section of "Viking" 10 was blown off by explosives when the rocket was descending.*

* *If the streamlining of the rocket is destroyed before it enters the denser atmosphere, the severed fragments will be cushioned by the air and will have a relatively softer impact.*



VIKING No. 10

The picture shows a Viking rocket, the tenth of 14 being built by The Glenn L. Martin Co. for the U.S. Navy, which reached an altitude of 136 miles on May 7, 1954.

The rocket is 42 feet long and weighs 7½ tons.

It was recently announced that a later Viking (No. 11), reached an altitude of 158 miles, thus establishing a further high-altitude record.

(A short note on earlier Vikings, together with a number of illustrations, appeared on pages 46–51 of the January, 1954, *Journal*.)

Most of the scientific information obtained from the rocket, however, was transmitted to the ground during the flight by means of a radio telemetering system. By use of this system, several hundred measurements were transmitted continuously during the flight and recorded automatically on the ground.

The U.S. Naval Research Laboratory, under the direction of Dr. Homer E. Newell, Jnr., Head of the Rocket Sonde Branch of the Laboratory, has been probing the upper atmosphere since early 1946 in a research programme which has contributed a great deal to the existing knowledge in this field.

The present aims of the programme are to extend knowledge of:

(1) the physical state of the Earth's atmosphere to as great an altitude as possible, with temperatures, pressures, densities, and composition as principal objectives of study;
(2) the fundamental nature and properties of the ionosphere and those processes which lead to its formation;
(3) solar and terrestrial radiation; and
(4) the physics of high energy particles by high altitude cosmic ray studies.

CORRECTION OF INTERPLANETARY ORBITS

By Derek F. Lawden, M.A.

SUMMARY

If a rocket fails to follow a previously computed trajectory in space, it will become necessary to correct its erroneous orbit by small thrusts from the motors. It is proved that, if the instant at which the correction is to be made has been chosen, the appropriate velocity increment to be given to the rocket is uniquely determined. A scheme for assisting the navigator in his task, by calculating numerical tables prior to the rocket's departure, is described and applied to the case of motion in a field due to a single attracting body. A numerical example is computed to illustrate the theory.

1. General Theory

The author has given elsewhere[1,2,3] equations which determine the rocket trajectory of least fuel connecting two terminals in a general gravitational field. The solution of these equations, corresponding to any future expedition into space, will be calculated by an automatic computer well in advance of the departure date and the task of the pilot and navigator will be to economize in fuel by employing the rocket thrust to keep the ship on the computed track. It has been pointed out by Porter[4] that very small unavoidable errors in navigation at the point of departure will, generally, lead to relatively large errors at the rocket's destination, unless these errors are corrected *en route* as soon as their effects are noticed by the navigator. Theoretically, immediately it is discovered that the rocket has been launched into an erroneous orbit, a new situation arises, in that the previously computed optimal track to the destination will no longer be a valid one and a complete reassessment of the position is necessary. This would involve a fresh calculation of the optimal track from the present position of the space-ship to its destination. Unless a great number of possible optimal tracks have already been computed, it is unlikely that the

desired result could be made available in time. Instead, the following procedure is suggested.

It has been proved that an optimal track will comprise a number of arcs of free orbit meeting at junctions at which sufficient fuel is expended to transfer the rocket from one orbit into another. Suppose J is the next junction point on the optimal track when an error is observed. The procedure is to alter the rocket's velocity in such a way that it moves into an orbit passing through J, its instant of arrival at J being arranged to be the same as that at which it would have arrived at this point by the optimal route. Upon arrival at the junction, a small velocity correction will be necessary to achieve agreement with the optimal programme. This correction can easily be incorporated into the larger velocity increment programmed to take place at J. The manœuvre we have described will result in the following of a non-optimal track, but the fuel wastage will be small. The wastage will, in any case, be a very small price to pay for the resulting simplification of the navigator's problem.

The instant at which the correction is to be made is open to choice. Since, however, the effects of the original error can be expected to increase with the time, we shall economize in fuel expenditure by effecting the correction at the earliest possible moment. The exact instant will have to be selected to be some little time after the navigator's report upon the trajectory divergence, to allow for the time which must be spent in calculation.

Let t_0 be the instant at which it has been decided to make a correction and let $((x_0, y_0, z_0)$ be the Cartesian co-ordinates of the point P which the rocket will occupy at this time. These co-ordinates can be computed by the navigator when the elements of the trajectory are available. Let t_1 be the instant at which it is desired to arrive at J and let (x_1, y_1, z_1) be the co-ordinates of J. The equations of motion of a body moving in a given gravitational field are three in number and each is of the second order. Their solution accordingly involves six constants of integration. Consider the solution corresponding to a body leaving the point P at time t_0 with velocity components (u_0, v_0, w_0). This may be written,

$$\begin{aligned} x &= x(t, x_0, y_0, z_0, u_0, v_0, w_0) \\ y &= y(t, x_0, y_0, z_0, u_0, v_0, w_0) \\ z &= z(t, x_0, y_0, z_0, u_0, v_0, w_0) \quad .. \quad .. \quad .. \quad (1) \end{aligned}$$

$x_0, y_0, z_0, u_0, v_0, w_0$ determining the integration constants. The velocity components (u_0, v_0, w_0) have to be selected so that when $t = t_1$, then $x = x_1$, $y = y_1$ and $z = z_1$, *i.e.* so that

$$\begin{aligned} x_1 &= x(t_1, x_0, y_0, z_0, u_0, v_0, w_0) \\ y_1 &= y(t_1, x_0, y_0, z_0, u_0, v_0, w_0) \\ z_1 &= z(t_1, x_0, y_0, z_0, u_0, v_0, w_0) \quad .. \quad .. \quad .. \quad (2) \end{aligned}$$

We have here three equations for the three unknowns (u_0, v_0, w_0) and hence, there will be a unique orbit joining P and J and satisfying the required conditions. There may, of course, be a number of distinct solutions of the equations (2) but only one will lie wholly in the neighbourhood of the optimal track and can

therefore be followed with little expenditure of fuel. At any point P, therefore, the necessary correcting action is uniquely determined.

Since the required trajectory PJ will not diverge greatly, either from the optimal track, or from the trajectory the rocket was actually following prior to its arrival at P, the solution of equations (2) may be assumed to be of the form $u_0 = u + \delta u$, $v_0 = v + \delta v$, $w_0 = w + \delta w$, where (u, v, w) are the velocity components with which the rocket arrives at P and $(\delta u, \delta v, \delta w)$ are the components of the velocity increment necessary and are small. Substituting in equations (2) and neglecting second order terms, we obtain

$$x_1 - x'_1 = \frac{\partial x}{\partial u}\delta u + \frac{\partial x}{\partial v}\delta v + \frac{\partial x}{\partial w}\delta w$$

$$y_1 - y'_1 = \frac{\partial y}{\partial u}\delta u + \frac{\partial y}{\partial v}\delta v + \frac{\partial y}{\partial w}\delta w$$

$$z_1 - z'_1 = \frac{\partial z}{\partial u}\delta u + \frac{\partial z}{\partial v}\delta v + \frac{\partial z}{\partial w}\delta w, \qquad \ldots \quad \ldots \quad (3)$$

where $x'_1 = x(t_1, x_0, y_0, z_0, u, v, w)$, etc. (x'_1, y'_1, z'_1) is the point J' at which the rocket will arrive at time t_1 if no correction is made. The computation of the position of J' by the navigator, will not be considered in this paper. Solving equations (3) for δu, δv, δw, we obtain

$$\frac{\partial(xyz)}{\partial(uvw)}\delta u = (x_1 - x'_1)\frac{\partial(yz)}{\partial(vw)} + (y_1 - y'_1)\frac{\partial(zx)}{\partial(vw)} + (z_1 - z'_1)\frac{\partial(zy)}{\partial(vw)}, \text{ etc.} \qquad (4)$$

These equations determine the velocity correction necessary at P.

The arguments of the coefficients $\partial(yz)/\partial(vw)$, etc. in equations (4) are $(t_1, x_0, y_0, z_0, u, v, w)$. These coefficients have therefore to be calculated at the instant $t = t_1$ on the erroneous orbit through P. This calculation cannot be performed therefore until the elements of this orbit are available. To avoid deferring the laborious computation of these coefficients to such a late juncture, it will be advisable to approximate to their values beforehand by finding the values they assume on the programmed track at various instants $t = t_0$. Employing these values in the equations (4), approximate values for the components of the velocity correction will become available in a few minutes. The fact that accurate values of δu, δv, δw are not used in the correction manœuvre, is of no great importance, since (i) it will not be easy to apply any correction demanded with great precision, and (ii) any inaccuracy can be allowed for later when corrections again become necessary.

In the next section we will consider the simple, but important case, when the gravitational field is due to a single attracting body.

2. Inverse Square Law Field

If the rocket is moving primarily under the attraction of a single body such as the Sun, the general problem formulated in the previous section is easily solved. We require a conic orbit passing through P and J such that the time of transit between these points is $T = t_1 - t_0$. This orbit will lie in the plane

OPJ, where O is the centre of attraction. Let OX be any reference line in this plane through O and let (r, θ) denote the polar co-ordinates of the rocket moving along the orbit PJ, relative to the pole O and the reference line OX. We shall assume the motion to be in an anti-clockwise direction. Let a be the semi-major axis, e be the eccentricity and ω the longitude of perihelion measured from OX for the orbit PJ. If (r_0, θ_0), (r_1, θ_1) are the co-ordinates of the points P and J respectively and E_0, E_1 are the respective values of the eccentric anomaly at these points, we have the equations

$$\begin{aligned} r_0 &= a(1 - e\cos E_0) \\ r_1 &= a(1 - e\cos E_1) \\ \tan \tfrac{1}{2}(\theta_0 - \omega) &= \sqrt{\frac{1+e}{1-e}} \tan \tfrac{1}{2}E_0 \\ \tan \tfrac{1}{2}(\theta_1 - \omega) &= \sqrt{\frac{1+e}{1-e}} \tan \tfrac{1}{2}E_1 \quad .. \quad .. \quad (5) \end{aligned}$$

If μ/r^2 is the attraction per unit mass acting on the rocket, we have, also, from Kepler's equation

$$E_1 - E_0 - e(\sin E_1 - \sin E_0) = \frac{\mu^{\frac{1}{2}}T}{a^{3/2}}. \quad .. \quad .. \quad (6)$$

The equations (5) and (6) are sufficient to determine the five unknowns a, e, ω, E_0, E_1, when r_0, θ_0, r_1, θ_1 are given. (r_1, θ_1) will be known prior to the commencement of the enterprise. (r_0, θ_0) must be obtained by the navigator from appropriate observations. The elements (a, e, ω) being known, the orbit PJ is determined and the velocity correction to be made at P can be found.

Approximate values of the five unknowns may be taken from the orbit which it is found the rocket is following. Thus, approximate values of a, e, ω are provided by the elements of this orbit and approximate values of E_0 and E_1 by the values taken by the eccentric anomaly at the points P and J' on this orbit, J' being the point such that $\angle J'OX = \theta_1$. Let $a + \delta a$, $e + \delta e$, $\omega + \delta\omega$, $E_0 + \delta E_0$, $E_1 + \delta E_1$ be accurate values of the five unknowns. Substituting in equations (5) and (6) and neglecting terms of the second order, we find that

$$\begin{aligned} \delta a(1 - e\cos E_0) - a\delta e\cos E_0 + ae\delta E_0 \sin E_0 \\ = r_0 - a(1 - e\cos E_0) \\ \delta a(1 - e\cos E_1) - a\delta e\cos E_1 + ae\delta E_1 \sin E_1 \\ = r_1 - a(1 - e\cos E_1) = G_1 \\ \delta\omega \sec^2\tfrac{1}{2}(\theta_0 - \omega) + \frac{2\delta e}{(1-e)\sqrt{1-e^2}} \tan \tfrac{1}{2}E_0 + \delta E_0 \sqrt{\frac{1+e}{1-e}} \sec^2\tfrac{1}{2}E_0 \\ = 2\tan \tfrac{1}{2}(\theta_0 - \omega) - 2\sqrt{\frac{1+e}{1-e}} \tan \tfrac{1}{2}E_0 \\ \delta\omega \sec^2\tfrac{1}{2}(\theta_1 - \omega) + \frac{2\delta e}{(1-e)\sqrt{1-e^2}} \tan \tfrac{1}{2}E_1 + \delta E_1 \sqrt{\frac{1+e}{1-e}} \sec^2\tfrac{1}{2}E_1 \end{aligned}$$

$$= 2\tan\tfrac{1}{2}(\theta_1-\omega) - 2\sqrt{\frac{1+e}{1-e}}\tan\tfrac{1}{2}E_1$$

$$\frac{3T\mu^{\frac{1}{2}}}{2a^{5/2}}\,\delta a + \delta e(\sin E_0 - \sin E_1) - \delta E_0(1 - e\cos E_0) + \delta E_1\,(1 - e\cos E_1)$$

$$= \frac{T\mu^{\frac{1}{2}}}{a^{3/2}} - (E_1 - E_0) + e\,(\sin E_1 - \sin E_0) = G^2 \quad .. \quad (7)$$

Since E_0 is the eccentric anomaly of the point P on the orbit (a, e, ω), we have

$$r_0 = a(1 - e\cos E_0) \qquad .. \qquad .. \qquad .. \quad (8)$$

and

$$\tan\tfrac{1}{2}(\theta_0 - \omega) = \sqrt{\frac{1+e}{1-e}}\tan\tfrac{1}{2}E_0, \qquad .. \qquad .. \quad (9)$$

i.e. the right-hand sides of the first and third of the equations (7) are zero.

Also, since J' is the point on the orbit (a, e, ω) having eccentric anomaly E_1 and longitude θ_1, we have

$$\tan\tfrac{1}{2}(\theta_1 - \omega) = \sqrt{\frac{1+e}{1-e}}\tan\tfrac{1}{2}E_1, \qquad .. \qquad .. \quad (10)$$

i.e. the right-hand side of the fourth of the equations (7) is also zero.

Solving the equations (7) for the corrections δa, δe, etc., we can now find more accurate values for the elements of the orbit PJ. If greater accuracy is required and time permits, these values of a, e, ω, E_0, E_1 can be substituted into the equations (7) and, after solution for δa, δe, etc., recorrected. By repeating this procedure, a solution, correct to any degree of accuracy desired, may be found.

If, however, it is desired to reduce the computation of δa, δe, etc., to the use of prepared tables, some inaccuracy being acceptable, we could compute these tables as follows. The values of a, e, ω occurring in the coefficients in the left-hand sides of the equations (7) may be approximated by the elements of the optimal trajectory, which will be available prior to departure. θ_1 is the longtitude of J and is therefore also available. E_1 may be approximated by the eccentric anomaly of J. θ_0, E_0 and T will depend upon the instant at which correction is to be made and will not be known in advance. Solving equations (7), we obtain formulæ of the form

$$\delta a = a_1G_1 + a_2G_2,$$
$$\delta e = e_1G_1 + e_2G_2, \text{ etc.,} \qquad .. \qquad .. \qquad .. \quad (11)$$

where the coefficients a_1, a_2, e_1, e_2, etc., depend upon the unknowns θ_0, E_0 and T, and the quantities G_1, G_2 have been defined in equations (7). Taking a series of values of θ_0, we may, in each case, approximate to E_0 and T as follows: Let P' be the point on the optimal orbit having the same longitude θ_0 as P. The eccentric anomaly of P' may be used to approximate E_0 and the time of transit between P' and J along the optimal orbit, may be used to approximate T. We can then tabulate the coefficients a_1, a_2, etc., as functions of θ_0 for the use of the

navigator. Aboard the rocket, the task of this member of the crew would be reduced to abstracting from the tables the appropriate values of the coefficients, calculating G_1 and G_2 (accurate values of all the quantities concerned must be used for this purpose), and substituting into the equations (11).

Having calculated the elements of the orbit PJ, the next step is to find the velocity change at P which will ensure transference into this orbit. In general, the plane of the orbit PJ will not coincide with the plane of the trajectory the rocket has been describing. However, for simplicity, we shall assume the planes coincident, leaving the more general case for later investigation.

Suppose that (a, e, ω) are the elements of the rocket's trajectory before correction and $(a + \delta a, e + \delta e, \omega + \delta\omega)$ are the same elements after correction. The radial and transverse components of the rocket's velocity at P (r_0, θ_0), when it is moving in the orbit (a, e, ω), are given by

$$v_r = \frac{\mu^{\frac{1}{2}} e}{a^{\frac{1}{2}}(1 - e_2)^{\frac{1}{2}}} \sin(\theta_0 - \omega)$$
$$v_\theta = \mu^{\frac{1}{2}} a^{\frac{1}{2}}(1 - e^2)^{\frac{1}{2}}/r_0 \quad .. \quad .. \quad .. \quad .. \quad (12)$$

respectively. The proof of these results will be found in Reference (5). Let $(\delta v_r, \delta v_\theta)$ be the increments in the velocity components (v_r, v_θ) consequent upon a transfer into the orbit PJ. Differentiation of the equations (12). shows that, to the first order,

$$\delta v_r = -\frac{\mu^{\frac{1}{2}} e \delta a}{2a^{3/2}(1 - e^2)^{\frac{1}{2}}} \sin(\theta_0 - \omega) + \frac{\mu^{\frac{1}{2}} \delta e}{a^{\frac{1}{2}}(1 - e^2)^{3/2}} \sin(\theta_0 - \omega)$$
$$- \frac{\mu^{\frac{1}{2}} e \delta\omega}{a^{\frac{1}{2}}(1 - e^2)^{\frac{1}{2}}} \cos(\theta_0 - \omega)$$
$$\delta v_\theta = \frac{\mu^{\frac{1}{2}} \delta a (1 - e^2)^{\frac{1}{2}}}{2r_0 a^{\frac{1}{2}}} - \frac{\mu^{\frac{1}{2}} a^{\frac{1}{2}} e \delta e}{r_0(1 - e^2)^{\frac{1}{2}}} . \quad .. \quad .. \quad .. \quad .. \quad (13)$$

Substituting for δa, δe and $\delta\omega$ from equations (11), we obtain formulae of the form

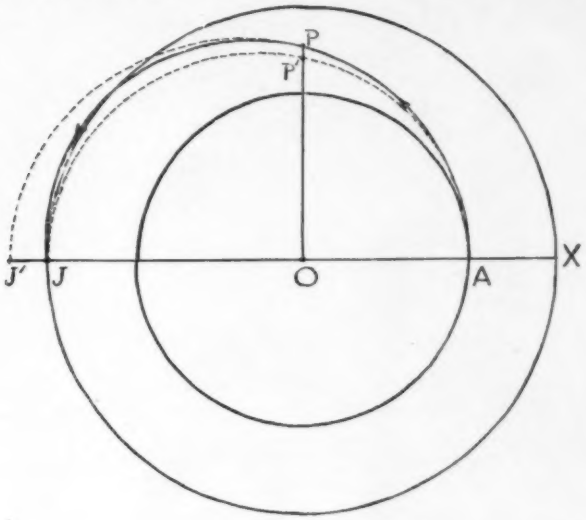
$$\delta v_r = p_1 G_1 + p_2 G_2$$
$$\delta v_\theta = q_1 G_1 + q_2 G_2 \quad .. \quad .. \quad .. \quad (14)$$

Tables of the coefficients p_1, p_2, q_1, q_2 will enable the navigator to calculate the velocity increments necessary, in a very short time.

3. A Numerical Example

To illustrate the theory of the previous section, we will compute the solution to the following problem. Assuming the orbits of the Earth and Mars to be circles of radii unity and 1·524 respectively, a rocket is to be transferred from the former to the latter *via* the cotangential ellipse. The thrust at the starting point A (see figure) is aligned correctly, but its magnitude is excessive, with the result that the rocket follows the erroneous orbit APJ'. AJ' is the major axis of this orbit and OP is semi-latus rectum. It is decided to make a correction at P. It is found that $r_0 = OP = 1{\cdot}27$. The correct semi-latus rectum OP' will be found to be 1·208. We are therefore assuming an error in this element

of about 5 per cent. Such an error would be caused by an error in the thrust at A of about 28·5 per cent. and is therefore larger than what might be encountered in practice.



Taking OA as the line of reference OX, it is clear that for the rocket's erroneous orbit $\omega = 0°$. Also, for this orbit, we calculate that $a = 1{\cdot}37$ and $e = 0{\cdot}27$. The eccentric anomaly of P is found to be $74° 20'$ and that of J' is $180°$. Approximate values of the unknowns appearing in the equations (5) and (6) are accordingly

$$a = 1{\cdot}37,\ e = 0{\cdot}27,\ \omega = 0°,\ E_0 = 74° 20',\ E_1 = 180°.$$

The co-ordinates of P and J are given by

$$r_0 = 1{\cdot}27,\quad \theta_0 = 90°,$$
$$r_1 = 1{\cdot}524,\ \theta_1 = 180°.$$

If T is the time which remains for travelling from P to J, we calculate that $\mu^{\frac{1}{2}}T = 3{\cdot}155$.

The next step is to substitute these values into the equations (7). A difficulty arises when we attempt to substitute into the fourth of these equations, in that a number of the coefficients become infinite. If, however, we eliminate E_1 from this equation by substituting from the equation (10), we find, after some rearrangement, that

$$\delta\omega + \frac{\delta e}{1-e^2}\sin(\theta_1 - \omega) + \delta E_1\left[\sqrt{\frac{1+e}{1-e}}\cos\tfrac{1}{2}(\theta_1 - \omega)\right.$$

$$+\sqrt{\frac{1-e}{1+e}}\sin{}^{2}\tfrac{1}{2}(\theta_1-\omega)\Big]=0.$$

Substitution can now be performed without difficulty.

Equations (7) will be found to take the form,

$$\begin{aligned}
&0{\cdot}927\delta a - 0{\cdot}370\delta e + 0{\cdot}356\delta E_0 &&= 0\\
&1{\cdot}270\delta a + 1{\cdot}370\delta e &&= -0{\cdot}216\\
&2{\cdot}000\delta\omega + 2{\cdot}158\delta e + 2{\cdot}079\delta E_0 &&= 0\\
&\delta\omega + 0{\cdot}758\delta E_1 &&= 0\\
&2{\cdot}155\delta a + 0{\cdot}963\delta e - 0{\cdot}927\delta E_0 + 1{\cdot}270\delta E_1 &&= -0{\cdot}137.
\end{aligned}$$

We deduce that

$$\delta a = -0{\cdot}131,\ \delta e = -0{\cdot}037,\ \delta\omega = -15^\circ\,42',\ \delta E_0 = 17^\circ\,18'$$
$$\delta E_1 = 20^\circ\,43'.$$

Applying these corrections, we have

$$a = 1{\cdot}239,\ e = 0{\cdot}233,\ \omega = -15^\circ\,42',\ E_0 = 91^\circ\,38',\ E_1 = 200^\circ\,43'.$$

To obtain a higher degree of accuracy, we substitute these values again into the equations (7) and obtain the following set of equations for the new corrections:

$$\begin{aligned}
&1{\cdot}007\delta a + 0{\cdot}035\delta e + 0{\cdot}289\delta E_0 &&= 0{\cdot}022\\
&1{\cdot}218\delta a + 1{\cdot}159\delta e - 0{\cdot}102\delta E_1 &&= 0{\cdot}015\\
&2{\cdot}743\delta\omega + 2{\cdot}759\delta e + 2{\cdot}610\delta E_0 &&= 0{\cdot}030\\
&\delta\omega - 0{\cdot}274\delta e + 0{\cdot}731\delta E_1 &&= -0{\cdot}012\\
&2{\cdot}769\delta a + 1{\cdot}353\delta e - 1{\cdot}007\delta E_0 + 1{\cdot}218\delta E_1 &&= 0{\cdot}069.
\end{aligned}$$

Whence,

$$\delta a - 0{\cdot}004,\ \delta e = 0{\cdot}018,\ \delta\omega = -3^\circ\,40',\ \delta E_0 = 3^\circ\,26',\ \delta E_1 = 4^\circ\,25',$$

and the corrected values of the unknowns are

$$a = 1{\cdot}243,\ e = 0{\cdot}251,\ \omega = -19^\circ\,22',\ E_0 = 95^\circ\,4',\ E_1 = 205^\circ\,8'.$$

If these values be substituted in the right-hand sides of the equations (7), it will be found that they all very nearly vanish. This indicates that satisfactory accuracy has now been obtained. The orbit PJ, defined by these values of the elements, has been drawn in the figure.

The total corrections which have to be made to the elements of the erroneous orbit are

$$\delta a = -0{\cdot}127,\ \delta e = -0{\cdot}019,\ \delta\omega = -19^\circ\,22' = -0{\cdot}338.$$

Substituting these corrections into the equations (13), and correcting to units of Km./sec., we calculate that the radial and transverse components of the necessary velocity correction are

$$\delta v_r = -0{\cdot}21 \text{ km./sec.},\ \delta v_\theta = -1{\cdot}08 \text{ km./sec.},$$

indicating a total velocity correction of 1·10 km./sec.

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(4) J. G. Porter, "Navigation Without Gravity," *J.B.I.S.*, **13** (2), 68–74, March, 1954.
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FILM OF MONKEY AND MICE IN FREE FALL

A short newsreel recently screened to members of the Society showed the monkey and 'floating mice' used in the recent Aerobee rocket experiments. The monkey and mice were used to study certain animal reactions similar to human reactions, and every possible means was taken to see that they suffered no ill effects. Fortunately they returned to Earth alive and unharmed.

This test was carried out at Holloman Air Force Base and White Sands Proving Ground, New Mexico, under the supervision of Air Force medical scientists from the Aero Medical Laboratory, Dayton, Ohio. From the knowledge gained, the Air Research and Development Command concluded human beings, being mammals, can function within the range of normalcy during rocket flight, but that physiological results obtained with monkeys and mice can only be applied with caution to men.

The pictorial sequences shown in the film were as follows:—

(1) The Rocket head, which was specially equipped for the experiment.

(2) Again, with the covering removed, so that the layout and spaces for monkey, camera and mouse container could be clearly observed.

(3) A technician accustoms the laboratory white mice to glass containers and the expected rotation. She places the two mice for the rocket head in the container. The mouse in the back part has a shelf to hang on to. The mouse in the front part (separated by a glass partition from the rear mouse) is in the compartment with a tiny ball.

(4) At the open rocket head, the camera is placed in position.

(5) The container with the two mice is placed below it and the oxygen tube for the mice attached. The camera takes the picture from the side of the container by means of a mirror, *not* shooting down on it.*

(6) Of the monkeys available for the experiment, Albert, not camera shy, was picked.

(7) The actual Aerobee Rocket head is prepared for launching with Albert, the monkey, anaesthetized and cushioned in special harness and equipment to record his reactions. He is carried up and installed in his spot.

(8) Inside the control room, its time for launching. Recording and tracking instruments are checked and on signal, the switches are thrown and the rocket is fired!

* The films show the container *from the side* with the *centre of gravity at the bottom of the screen*.—Ed.

(9) Ascending to almost 38 miles at a speed of approximately 2,000 miles per hour, the rocket ascends into the upper atmosphere with its living cargo.

(10) Back in the control room, a special graph records the monkey's heartbeats throughout the flight.

(11) Inside the rocket, mice in their container are subjected to about 15 *g*—producing an effect of 15 times their normal weight for less than a second —then subjecting them to a pressure of 3 or 4 *g* for 45 seconds during the initial speed up.

(12) Watching the ball in the front container with the mouse, which can be seen to be floating free within the container, whereas its normal position is bottom centre. Both mice are actually 'floating free'—the zero gravity state—as they scramble against the partition between them. The rear mouse, using the shelf for a hold, is tossed around less, especially during the time the chamber starts rotating.

(13) The shock chute and a second chute open as the container falls clear of the rest of the rocket.

(14) On the Earthward drop, the mice and the ball are pulled to the bottom of the container again by the action of gravity.

(15) A helicopter follows the fall of the rocket head to recover the monkey and mice so they will not be harmed by the heat of the desert in which they have landed.

(16) Albert having returned to Earth safe and sound is taken out of the rocket head. The mouse container is also recovered. Albert shows no ill effects as he looks around.

(17) After being flown back to the Lab., the mice are taken from the container, unhurt, and scamper around in their box.

(18) A month later, Albert returns to the rocket head and calmly munches a titbit as he surveys the scene of his scientific rocket ride. Like human volunteers, Albert has done his bit for science.

B.I.S. NEWS

Nominations for Council, 1954-5

In accordance with the provisions of Article 15 of the Society's Constitution, one-third (i.e. *four*) Members of the Council (Messrs. D. J. Cashmore, J. Humphries, W. N. Neat and Dr. L. R. Shepherd) will retire from office at the Ninth Annual General Meeting, which will be held on Saturday, December 4, 1954, at the Kent Room of Caxton Hall, London S.W.1, commencing at 6.0 p.m.

Nominations are invited from members for election to the Council for next session.

Signed nominations should be forwarded to the Secretary as soon as possible, and in any event, not later than October 23, 1954.

Voting papers will be prepared and forwarded to all members for completion and return before the date of the meeting.

21st Anniversary Celebrations

In October, 1954, the B.I.S. reaches the 21st anniversary of the date of its

formation and the Council has determined that it is proper for the occasion to be marked by celebrations both in London and the branches.

In order that Members of the Council, the Secretary and Branch Representatives and Members may attend as many as possible of the functions, it has been decided that the celebrations shall be spread over the whole of the month of October, particularly as this will also make it possible for a small exhibition to be arranged and sent to each branch in turn.

The probable dates are as follows:—

October	2, 1954.	Bristol.	October	23, 1954.	Manchester.
,,	9 ,,	Birmingham.	,,	30 ,,	Leeds
,,	16 ,,	London.			

It has been suggested provisionally that the London area celebrations comprise a special dinner, conversazione, and short film show, followed by a social evening—with facilities for dancing if desired.

Members having any other suggestions for functions which they would like to have considered are invited to forward these to the BIS Secretary.

Further particulars will appear in the *September* Journal.

Short Paper Evening

The Council has decided to include a "Short Paper Evening" in the 1954–5 London Lecture Programme and to extend an invitation to all members who would be interested in preparing short papers to be read by the Society on any aspect of space-flight which is of particular interest to them.

There is no restriction as to the particular subject matter to be dealt with, but it is important that each paper should not take longer than 10 minutes to read, followed by another 10 minutes in discussion.

Members interested in submitting papers should notify the B.I.S. Secretary, giving the title and synopsis of contents, and mentioning any special treatment and other points of interest, in order that the final programme may be arranged.

Western Branch Exhibition

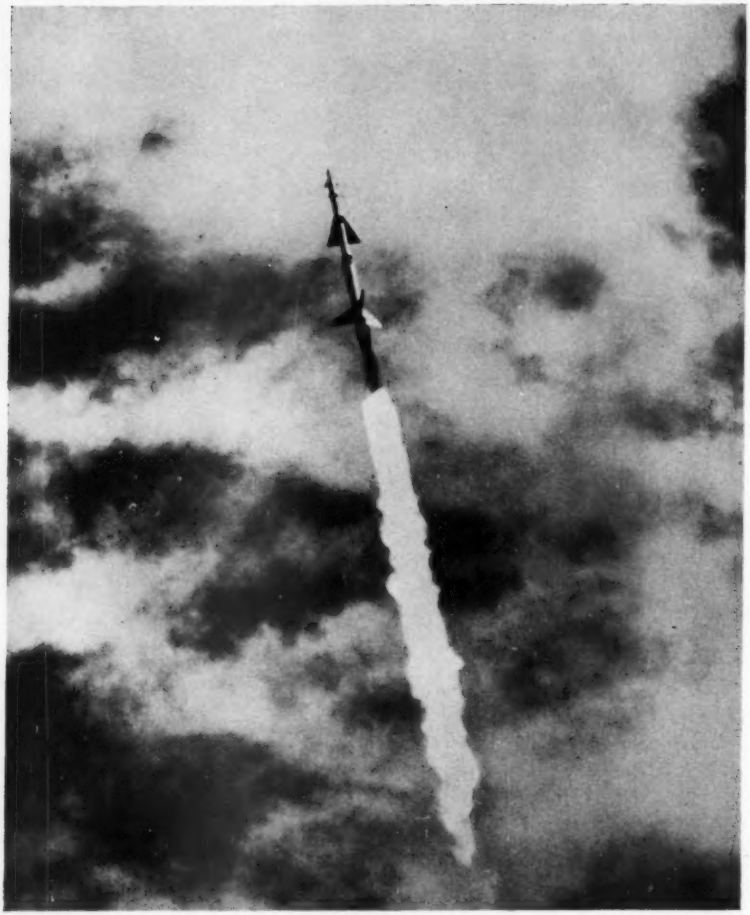
On April 24, 1954 about 200 people attended an Exhibition put on by the Provisional Western Branch designed to make available to the general public up-to-date information on rocketry and present ideas on space flight.

The main hall of the Folk House, College Green, was obtained for the occasion, and boards containing photographs were placed behind tables which contained models and other material. A large model of the 3rd Stage of the von Braun rocket was completed and exhibited by Messrs. S. W. Greenwood and J. Daniel.

The members assisting spent a very busy afternoon providing explanations to interested enquirers, and particular thanks are due to those who rose so nobly to the occasion in order to make the Exhibition a success.

Presentation of Painting to the Society

The Council wish to acknowledge with grateful thanks a presentation from Mr. Chesley Bonestell of the original of his painting of a spaceship 50 miles above the lunar surface, which appeared on page 51 of *"Across the Space Frontier."*



The "Nike"

A booster charge has started the Army's anti-aircraft guided missile, "Nike" on its supersonic quest for a flying target. The lower portion is expended after an initial thrust, and the missile proper continued toward its target, guided by an electronic "brain." The Western Electric Company produced electronic equipment which guides the missile. The rocket itself was developed and produced by Douglas Aircraft Company.

Index to Pre-war B.I.S. Journals

The Society has recently prepared an index (in duplicated format) of volumes 1–5 of the B.I.S. Journals, all of which were issued before the war.

The total number of pages published during this period (1934 to 1939) was 188, which compares with 392 pages published during 1953 in volume 12 alone.

Copies of the index can be obtained by any interested member on application to the B.I.S. Secretary.

Use of Temporary and Service Addresses

The general practice of the Society is to send all communications to the registered permanent addresses of members, leaving them to make private arrangements for mail to be forwarded if they so desire.

The reason for this course is that much confusion frequently arises where temporary addresses are used, owing to the fact that the Society's printers, who undertake the despatch of Journals, use an addressing plate system, and it takes some weeks to get plates altered.

Since temporary addresses tend to change frequently, and usually without prior notice, the addressing plates often cannot be altered in time and Journals go astray. This causes of additional correspondence and expense, which might have been avoided, and is also frequently a source of annoyance to the member concerned.

In view of this it is recommended that members register their permanent addresses wherever this is practicable, in their own interests, and particularly where temporary addresses are of normally short duration.

Photographs available to members

A number of members have enquired in the past if prints of illustrations in the Journal could be made available to members, and arrangements have recently been completed whereby this can be done.

Pictures are available in two sizes i.e. $10'' \times 8''$ (price 5/- each) and $20'' \times 16''$ (price 15/- each): this latter size is suitable for framing and makes an excellent picture for use in studies, etc.

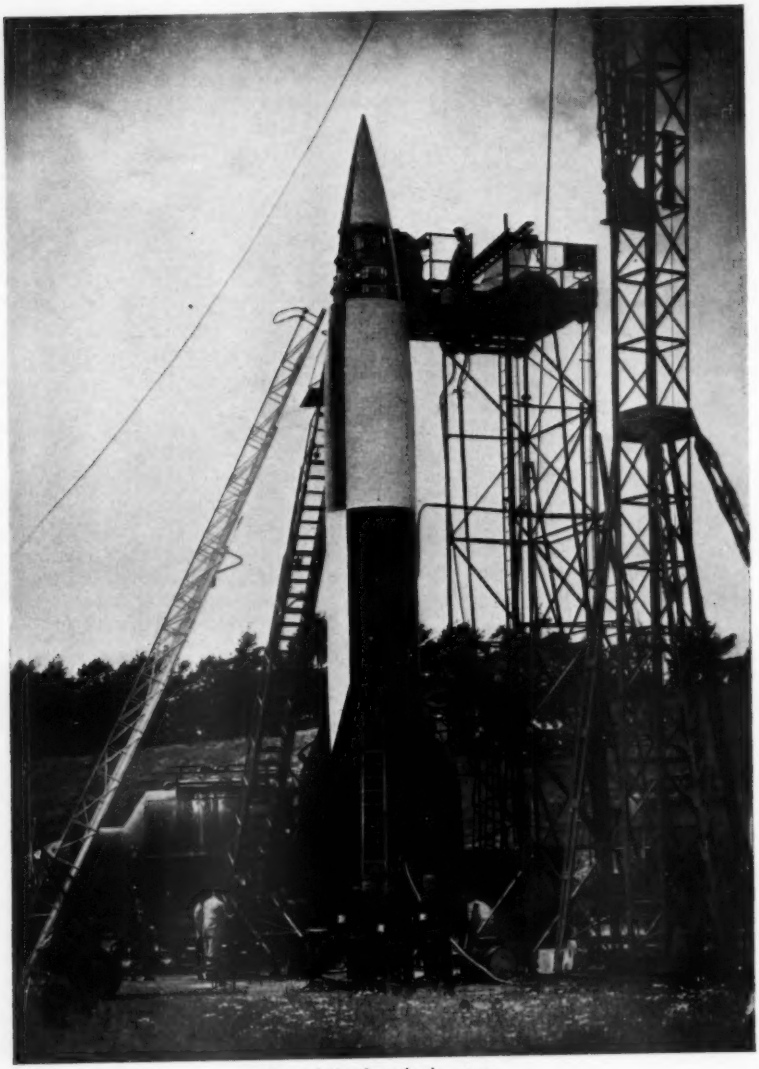
The attention of members is particularly drawn to the fact that all pictures are protected by copyright, and permission for reproduction may be granted only on making written application to the Secretary of the Society.

A list of photographs available can be obtained from the Secretary at 12, Bessborough Gardens, London, S.W.1, to whom orders and remittances should be addressed.

Abstracts Lending Library

As from July 1, 1954, the Society's Abstracts Lending Library will be housed at 12, Bessborough Gardens, London, S.W.1, and requests for the loan of material should be addressed there after that date.

The Council recently passed a note of thanks to Mr. J. Humphries for the excellent way he has carried out the duties of Abstracts Librarian for a number of years past.



One of the first A.4's, 1942.

Bankers Order and Payment of Subscription

The attention of members with bank accounts is drawn to the fact that subscriptions can be remitted automatically each year merely by completing the Society's Bankers Order form, which saves much trouble to the member concerned, and is of considerable assistance to the Society at a very busy time.

The answers to several queries recently raised by members are given below as they may be of general interest:—

(*a*) Subscriptions may be remitted in advance at any time during the year.

(*b*) Bankers Order forms may be completed to arrange for payment on any date during the year, provided that such payments are made in advance, or (where the payment is made for the current subscription year) the date of payment lies between January 1 and March 31.

Films

From time to time inquiries are received regarding the loan of films, and it is hoped that the following information will prove of interest to members.

(*a*) *The German A4 Rocket.* This is a technical film on the construction and handling of German V2 rockets, and can be obtained on loan for a small charge from the Army Kinema Corporation, 36, Dover Street, London, W.1.

(*b*) *Faster Than Sound.* This film of the Vicker's Transonic Rocket Missile can be obtained on hire from the Central Office of Information, Norgeby House, 83, Baker Street, London, W.1.

(*c*) *Rocket Flight.* This film is at present held by the Air Ministry and is not available, unless it can be screened in conjunction with some R.A.F. Organization.

(*d*) Several astronomical films, e.g. *Solar Prominences*, can be borrowed from the Royal Astronomical Society, Burlington House, London, W.1, provided that the application is made through a Fellow of that Society. (This usually presents no difficulty to B.I.S. Branches.)

(*e*) *The Viking Rocket* can be obtained on loan from the Naval Attaché, U.S. Embassy, Grosvenor Square, London, W.1.

Members who are aware of other relevant films are invited to send particulars to the B.I.S. Secretary in order that these can be brought to the attention of other members.

(*f*) *Atomic Physics.* This consists of five parts, and may be hired from G.B. Equipments Ltd., 70, Hanover Square, W.1.

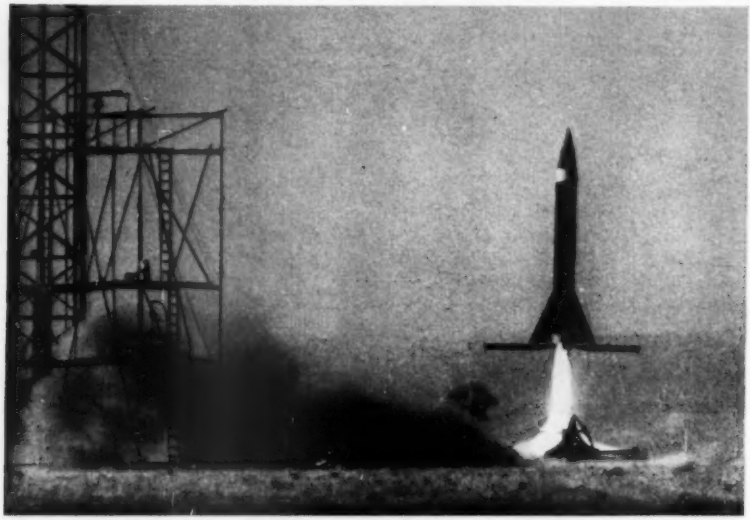
Astronomical Photographs and Slides

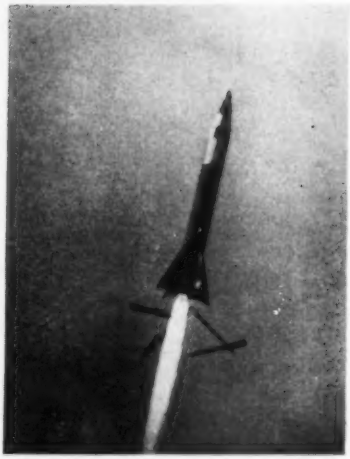
Catalogues of astronomical photographs and slides can be obtained on request from the following:—

(*a*) The Director, Science Museum, Exhibition Road, London, S.W.7.

(*b*) The Secretary, Royal Astronomical Society, Burlington House, London, W.1.

The Science Museum Catalogue relates almost entirely to the pictures on display at that Museum, whereas the R.A.S. Catalogue is quite substantial and includes a number of photographs taken with the 200" Hale telescope.





The "Veronique"

This French missile has reached a height of 40 miles with a payload of 123 lb. Launching is made from a simple platform, four cables unwinding from a drum fixed to the launching table being employed to obtain a stable ascent path.
Outriggers at the base of the four fins serve as attachment points to the cables, which are shown being jettisoned by the action of explosive bolts controlled by a clockwork timer.

"A.R.S. Journal"

As the number of requests for copies of the *A.R.S. Journal* now equal the total number of copies available, the Council has resolved that a waiting list be maintained for the future.

Introduction of New Members

The Society's strength and influence depends to a very large extent upon the continued introduction of new members, and it is of great value when members use their influence to make known the work and publications of the Society.

Particulars of the Society can be obtained at all times from the B.I.S. Secretary, who will be pleased to forward them to members personally or directly to their friends if desired.

Personal

Mr. Sydney Allen, M.I.Mech.E., A.F.R.Ae.S., has been appointed Chief Engineer of the Rocket Division of Armstrong Siddeley Motors.

Book List No. 12

Members are reminded that copies of the current Book List can always be obtained from the B.I.S. Secretary on request.

Correspondence Corner

The following extract is from a letter by "an organisation of electronic, mechanical, aeronautical and industrial engineers" having for its objects an interest in flying saucers and the development of an electro-magnetic aircraft:—

"We are in frequent contacts with George Adamski and Truman Bethurum, both of whom have had numerous personal contacts with ships and persons from Venus, Mars, Saturn and Clairon. We have carefully investigated both of these men and are in a position to confirm their stories in full."

("Clairon" is a planet so situated in its orbit as to be invisible from the Earth—ED).

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Experimental A.4 assembly at Peenemünde, 1943.

Experimental A.4 assembly, Peenemünde, 1943.

NOTES AND NEWS

Australian Rocket Exhibition

On May 14, 1954, the North Salisbury Exhibition was opened by the Premier of South Australia, Hon. T. Playford. The Patron was Dr. C. F. Bareford, Chief Superintendent Long Range Weapons Establishment, and a great deal of equipment used in the guided weapons industry was shown. Exhibits included a German V2 and other rockets, a Jindivik, a scale model of Woomera Village, and a field grouping in which a guided missile was being launched to intercept an aircraft.

A colour film of rocket firings at Woomera was shown continuously to crowded audiences.

Other equipment on view by L.R.W.E. included an acceleration camera, accelerometer, photographic and other displays.

Fairey Aviation Co. (Aust) showed Hydraulic Servo Unit Testing, as used to simulate conditions of control in the flight of guided missiles, together with a rocket test vehicle as fired at Woomera, with a cut-away showing the internal components.

E.M.I. showed remote control apparatus for the destruction of missiles in flight, which was demonstrated with a satisfactory bang from the model used.

It would seem that this was probably one of the largest of such displays ever held, in contrast to the M.O.S. stand at Farnborough last year.

It is of interest to speculate, in view of present heavy security regulations, how it is possible for such an Exhibition to be put on in Australia, compared with the impossibility of obtaining information in this country.

News from Abroad

The following is digest of news received from other Societies abroad interested in the problems of space flight:—

(*a*) *American Astronautical Society*. This new American Society was incorporated on March 3, 1954 and now has a membership 50.

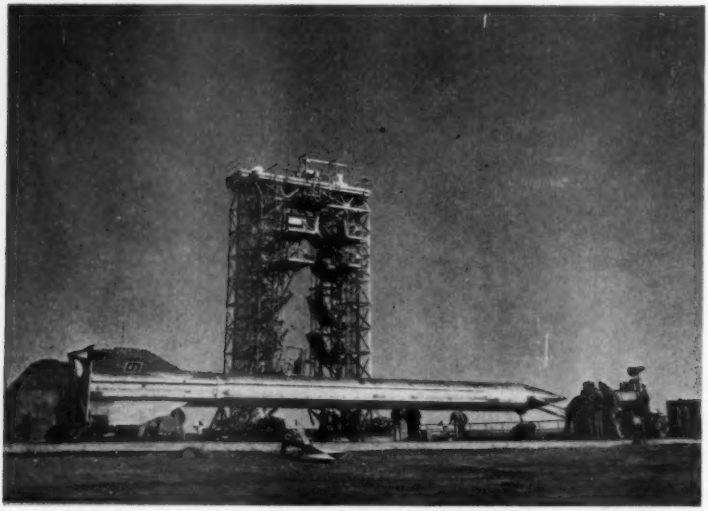
The preliminary meeting was held on January 22, 1954, when it was resolved that the Constitution be prepared by Mr. Oscar Schachter, who was also the speaker at the first general meeting, which drew an attendance of approximately 1,000.

(*b*) *American Rocket Society*. Mr. A. G. Haley has been elected President of the A.R.S. in succession to Mr. F. C. Durant III.

(*c*) *Danish Interplanetary Society*. The Dansk Selskap for Rumfart-Forskning (Danish Society for Space-flight Research) has now changed its name to Dansk Interplanetarisk Selskap (Danish Interplanetary Society).

(*d*) *Detroit Rocket Society*. Information has been received that the quarterly Journal of the D.R.S., "Rocketscience" has now been suspended.

(*e*) *New Zealand Scientific and Interplanetary Group*. A small group has been formed with the above title, operating from 55, Tedder Avenue, Christchurch, E.3, New Zealand. It will shortly seek incorporation.



A Viking is moved to the launching site in its towing cradle and erected in a gantry from which technicians can make further and final checks.

Anti-aircraft guided missile "Wasserfall" developed at Peenemünde, 1943/45. Note target-tracking radar in foreground.

(*f*) *Socieded Argentina Interplanetaria.* Bulletin No. 5 of the above Society (dated July, 1953) runs to 28 printed pages, a great advance on the previous leaflets which consisted of four pages only.

(*g*) *Sociedade Interplanetaria Brasileira.* This Society was legally registered recently, though it has been in existence since February 17, 1953. The present membership is 57, and recent activities include a series of 10 lectures on Modern Astronomy presented from January 13 to March 17, 1954.

(*h*) *Swedish Interplanetary Society.* The S.I.S. has just published its first printed Journal, which runs to 8 pages and is the same size as the A.R.S. Journal.

Early Films on Space-Flight

TV viewers recently had an opportunity of appreciating that space-flight films are not of such recent origin as is generally supposed, when they saw "*A Trip to the Moon,*" produced with much trick photography by Georges Melies in 1902.

Another early (silent) film was "*Frau im Mond*" (known variously in England and America as "*The Girl in the Moon*" and "*By Rocket to the Moon*") which was produced by Fritz Lang in 1928 and ran for about 2 hours. Unfortunately, we have not been able to trace any existing copies of this film, and it is understood that a great many copies were destroyed by the Gestapo before the war, who also confiscated models of the rocket built for the film.

Although some of the final space-flight scenes were included as a closing sequence in the film "*Rocket Flight,*" the story of the film is not well-known.

Briefly, this concerns a Professor, who believes the Moon's crust is covered with gold, and a secret council of business men who finance the project. Five men (one a stowaway!) and a girl, reach the Moon, but the Professor falls down a crevasse, and since dissensions and other complications emerge, the girl and one of the men has to stay behind.

The technical advisor to the film was Professor Oberth, and the studio made sets showing the rocket departure, scenes inside the rocket during its flight, etc., were quite noteworthy, and were described in the August and September 1943 issue of "*Astounding Stories.*"

From the World's Press

In February it was announced by Mr. H. Beale, Australian Minister of Supply, that an Australian "Upper Atmosphere Research Committee" had been formed to investigate conditions in the upper atmosphere up to an altitude of 200,000 ft. After a quick surge of interest we felt that we could give only half-hearted applause. We felt that it was about time something of this nature was commenced, but could not understand why the altitude had been limited to 40 miles. British military rockets, using the Rockoon principle, could have been launched to 40 miles long ago had the necessary authority been given and the equipment made available. It is inexplicable why official interest in this vital defence matter of upper atmosphere physics is only currently appearing.

The announcement further stated that the firings—presumably of rocket missiles—are to be made from Woomera. Again this seems to represent an

exceedingly limited outlook, for surely the greatest need nowadays is for synoptic measurements, especially over the European area, where the defence aspects are vitally important. Isolated experiments concerning the upper atmosphere have been covered adequately by American experiments and now data are required on the variation in these conditions, with latitude and with terrestrial rotation and revolution, and, finally, with solar conditions.

* * * * *

Major Charles Yaeger—who should know what he is talking about, having piloted the Bell X-1 rocket plane at 1,650 miles an hour—is reported by *The Cape Times* of December 12, 1953 as saying, "I do not think there is any limit to how fast a pilot can fly." Comforting words indeed! Especially when we remember those many critics who, having most likely never travelled themselves in anything faster than a railway train, have so often foretold in great detail the grim jellyings and other horrid endings destined for those misguided people who may be foolish enough to risk their puny bodies in rocket-driven spaceships!

* * * * *

Lieut.-General J. Doolittle, who made the first bomber raid on Japan, has recently made some interesting statements. *The East London Dispatch* dated February 19, 1954, quoted him as prophesying spaceships within the next 50 years and, according to a report in *The Recorder* (March 5, 1954) he is stated to have said that it was quite likely that Soviet Russia was ahead of the United States in the development of long-range missiles.

This naturally leads us to the crop of current rumours from behind the Iron Curtain, a veritable flood—if the reader will forgive the mixed metaphor—of reports which form excellent material for sub-editors to headline as "Race to the Moon" (*Church Times*, January 22, 1954), "Spaceships 'Near Reality,' Says Moscow" (*Cork Examiner*, January 1, 1954), "Belief that Soviet has Built Spaceship" (*Natal Mercury*, January 18, 1954).

The Jersey Evening Post, January 18, 1954, reported that Alexander Mesmeyanov, President of the U.S.S.R. Academy of Sciences, had stated that science has developed to such an extent that sending a stratoplane (*sic*) to the Moon is wholly feasible. And according to *The Hindu* for January 1, 1954, Academician J. F. Alexandrov answered a question concerning the possibilities of interplanetary travel which was put to him at the Indian Science Congress. He replied that Russia is not neglecting this research and he implied that "saucers" were a disease of the West.

From the many reports and from the formation of an astronautical department of the Central U.S.S.R. Flying Club in January, it would now appear that Soviet magazines and newspapers, maybe even Soviet scientists, are at last being allowed officially to talk about ideas of space-flight. It seems that, after lumbering noisily around the western world for the last decade, the interplanetary "band-wagon" has bulldozed through the Iron Curtain. Prominent Soviet citizens are following in the footsteps of their more astute western commercial contemporaries and are leaping on it as fast as they can. They are finding that being an interplanetarian may nowadays be respectable.

The military space-vehicle project still has its followers. The latest pronouncement comes from Mr. S. F. Pryor, executive vice-president of Pan American World Airways, reported in *The New York Times* of January 23, 1954. Mr. Pryor contends that if any nation bent on world conquest should perfect an Earth satellite it may be able to reduce any country it likes to ashes.

We would rather regard the boot as being on the other foot. While nations are striving to build up atomic armaments and defence systems of guided missiles, it is unlikely that appropriations will be made available for what must surely, at first, be only an expensive scientific experiment, the establishment of an instrumented Earth-satellite vehicle. We would advise Mr. Pryor to heed the paper presented to the Manhattan meeting of the American Rocket Society and reported in *Time* for May 3, 1954. Professor L. H. Thomas gives the military satellite its final death-blow. He shows how easily it could be destroyed by sending another missile into the same orbit, but revolving in an opposite direction and thus giving high relative speeds between the two bodies. No attempt would be made to hit the satellite vehicle, the missile would merely be constructed and exploded to form a swarm of small particles, it would become a stream of artificial meteors. By waiting for the passing of a few revolutions the defenders would have the satisfaction of knowing that the artificial satellite was rapidly being converted into an elaborate colander!

* * * * *

The Manchester Evening Chronicle of January 15, 1954 carried one of those brief news items which periodically takes our breath away. A Bury textile manufacturer was reported to have stated at a lecture that ". . . spaceships are all right to amuse children, but their contribution to science is of little use." He clinched the argument against space-flight by saying that a voyage to the Moon will not reveal any more about our satellite than we already know. As far as we are aware, spaceships have, indeed, not yet made any contributions to science, simply because they do not exist, but we are sure that many of our selenologists would like to contact the gentleman in question in order to clear up those many points concerning the Moon on which he appears to be so much better informed than his contemporaries.

* * * * *

We were also rather interested in the announcement of the construction of a clock to tell the time on Mars. Why, when all the astronomical tables use G.M.T., should anyone want to complicate matters further by insisting that space-travellers must observe Martian time and carry extra dead-weight in the form of special clocks to enable them to do so? The interplanetary clock is claimed to tell the time, day, and year on Mars. We think that the obvious question—while still upset by several current Earth calendars, zonal time, sidereal time, summer and winter times—is what if the Martians (*see* "saucer" books for latest details) do not agree with *our* division of *their* time, for example, why should a Martian month consist of 56 days? Surely it would be much better to preserve Greenwich time and use the revolutions of Deimos and Phobos for any time checks which visitors to the Red Planet may need.

A more practical example of the contemporary interplanetary modification was reported in the *Manchester Guardian* during March. Resourceful U.S. doctors had made a transparent helmet labelled "Spacechief" in the form of a mask for administering anaesthetics. Juvenile terrors of anaesthesia in tonsilectomy were replaced by the eagerness of youthful patients wanting to don the special space headgear, but we are not advised if their resulting dreamland was consequently interplanetary in its scope or merely followed the usual pattern.

* * * * *

A bureacratic argument arose in the *Manchester Daily Dispatch* dated January 16, 1954, following the failure of a rocket built by some amateur experimenters. The feature writer had contacted various Government departments in order to ascertain if there were any regulations governing the departure of space-vehicles from the British Isles. Needless to say, telephone calls to Whitehall produced the vaguest replies and the conclusion had been arrived at that, providing your spaceship had been licensed for the manufacture of explosives (viz. admixture of the propellants) under the Explosives Act of 1875, you could take off and fly wherever you wished. A slight proviso insisted that under many common laws you must not cause any damage or breach of the peace, etc., and more modern legislation insisted that you should not endanger aircraft. It appears that spaceship piloting and flying is one of the few things for which a qualification and a licence are not needed. Perhaps this is one of the reasons why so many would-be pilots write to us in the hope that their names may be placed on this list which we are reputed to keep.

* * * * *

It was with great pleasure that our eyes scanned the contribution by Mr. Cleaver which appeared on the familiar pink newsprint of the *Financial Times* (March 12, 1954), an august newspaper which concentrates on matter which may appear very mundane to many interplanetary enthusiasts, but which basically covers financial, industrial and economic affairs. We were particularly pleased that Mr. Cleaver had brought the problems of space-flight to the notice of the financiers and the economists because, in the final analysis, they may be most important people as far as space-flight is concerned. After all, even if the technicians have the know-how for building a spaceship, they will never be able to do so unless they have the economic backing from the people who control the purse-strings of the world. The article, "Economics of Space-flight," showed clearly that the beginnings of a useful space-flight programme does not need impossible finances and might, indeed, be much less than the present annual American budget for expenditure on all aspects of atomic energy.

Fifth Column

Information has been received at H.Q. that Dr. Singer's Minimum Orbital Unmanned Satellite, Earth (MOUSE) may find itself eventually attacked by a Celestial Atomic Trajectile (CAT).

ABSTRACTS

Edited by J. HUMPHRIES

Abbreviations of titles of journals were given in the May, 1950, issue of the *Journal*, and addenda have appeared in subsequent issues. The following is a further addendum to the list:—

Insts. Autom.	Instruments and Automation.
Leaf. Astr. Soc. Pacif.	Leaflet of the Astronomical Society of the Pacific.

ASTRONAUTICS

(213) **The artificial moon as an auxiliary in geodesy and astronomy.** A. BERROTH. *Geofis. Pura. Appl.*, **22**, 139–146 (1953). (*In Italian.*) Discussion of the problems involved.

(214) **Interplanetary travel.** B. LYAPUNOV. *Nauka I Zhizn'*, **20**, 33 (*June*, 1953). (*In Russian.*)

(215) **Advances of the perigees of Earth-satellites predicted by general relativity.** L. LA PAZ. *Publ. Astr. Soc. Pacif.*, **66** (388), 13–16 (*Feb.*, 1954). Mathematical investigation of the problem. While the advance of the lunar perigee is too small to provide an observational check on the validity of general relativity, the same would not be true of the perigeal advances of satellites moving about the Earth at mean distances small in comparison with the mean distance of the Moon.

ASTRONOMY

See also abs. nos. 213 and 215.

(216) **Solar space.** W. PROELL. *J. Space Flight*, **5**, Part I. A new map of solar space (8), 1–9 (*Oct.*, 1953). Part II. The Probability of planets in solar space (9), 1–7 (*Nov.*, 1953).

(217) **The rotation of the planet Venus.** W. SANDNER, *Vega*, **1**, 37–39 (*Oct.*, 1953). Review of past and present investigations.

(218) **Jupiter, Saturn and their local cosmology.** R. SCHATZMAN. *Astronomie*, **67**, 373–376 (*Oct.*, 1953). (*In French.*) Summary of recent work.

(219) **Unusual lunar shadows.** D. P. AVIGLIANO. *Strolling Astronomer*, **7**, 153–155 (*Nov.*, 1953). Description of some interesting shadow effects, possibly caused by unusual surface structure or local atmospheric effects.

(220) **How are things among the asteroids?** A. G. MOWBRAY. *Leaf. Astr. Soc. Pacif.* (297) (*Jan.*, 1954). Summary of recent investigations.

(221) **Observations of the transit of Mercury, 1953, November 14.** E. H. NOON, O. C. RANCK and W. SANDNER. *Vega*, **1**, 45–48 (*Jan.*, 1954).

BIOLOGY AND MEDICINE

(222) **Theory of protection of man in the region of the primary cosmic radiation.** *H. J. Schaefer. U.S. Naval School of Aviation Medicine Proj. No. N.M.* 001059.15.06, 17 pp. (*Aug.* 5, 1953.)

CHEMISTRY

(223) **Self-heating of hydrogen peroxide storage vessels.** E. S. SHANLEY. *Industr. Engng. Chem.*, **45**, 1520–1524 (*July*, 1953). The first part is a theoretical study of the heat balance in hydrogen peroxide storage tanks and the second part contains recommendations on handling and storage.

(224) **On the lowering of the freezing-point of tetranitromethane using chemical means, and a preliminary note on the system tetranitromethane-nitrogen peroxide.** R. M. CORELLI. *Aerotecnica*, **33**, 391 (*Dec.*, 1953). (*In Italian.*) Addition of nitrogen peroxide to tetranitromethane lowers the freezing point from 13° C. to below 0° C. and the chemical activity of the oxidant is also increased.

PHYSICS

See also abs. nos. 213 and 222.

(225) **The story of cosmic rays.** W. F. G. SWANN. *Sky and Telescope*, **13**, 108–111 (*Feb.*, 1954), 154–157 (*March*, 1954), 185–188 (*April*, 1954). Survey of cosmic rays and associated phenomena.

PROJECTILES

(226) **Guided missiles.** *Aero. Dig.*, **68** (3), 22–25 (*March*, 1954). Tabulated data on and illustrations of Bomarc, Terrier, Firebird, Hermes, Nike, Lark, Matador, Sparrow and Regulus.

(227) **G. E. reveals Hermes missile milestones.** D. A. ANDERTON. *Aviation Wk.*, **60** (10), 26–27, 30–32 (*March* 8, 1954). Project Hermes was started in November, 1944, and included in the proposed series of missiles were the A.1, take-off photographs of which are shown, and C1, a 3-step intercontinental missile. Many V2's have also been fired under the project, including the Bumper series. Static facilities at the Malta test-station include 150,000 lb. thrust test-stands.

ROCKET MOTORS

See also abs. no. 241.

(228) **Apparatus for cooling combustion chambers of movable power plants with an oxidising agent.** M. BOUFFART. *U.S. Pat. No.* 2,641,904. (June 16, 1953.) Closed circuit flow system cooling combustion chamber by vaporisation of oxidiser and recirculating coolant to obtain high cooling flow rates.

(229) **Propulsion apparatus actuated by successive charges of detonating materials.** R. H. GODDARD. *U.S. Pat. No.* 2,651,171. (Sept. 8, 1953.) Design for explosion area surrounded by spaced 45° deflecting vanes to give substantially unidirectional gas flow.

(230) **Two-liquid combustion chamber for rocket apparatus.** R. H. GODDARD. *U.S. Pat. No.* 2,654,997. (Oct. 13, 1953.) Spherical chamber with tangential introduction of propellants.

(231) **Fluid-cooled, refractory, ceramic-lined rocket structure.** K. C. NICHOLSON. *U.S. Pat. No.* 2,658,332. (Nov. 10, 1953.) Refractory nozzle walls with embedded cooling tubes passing fluid into porous refractory walls at throat.

(232) **On the present possibilities of rocket motors.** V. SIVORI. *Aerotecnica*, **33**, 367–372 (*Oct.*, 1953). (*In Italian.*) Principles of operation and characteristics of chemical rocket motors, their classification, typical applications and problems arising. Some numerical data given for various types and attainable performance with single- and multi-stage rockets discussed.

(233) **Rockets on the Mojave.** *Flight*, **65**, 44 (*Jan.* 8, 1954). Description of U.S.A.F.'s static-test station. Rocket motors are tested vertically on test-stands built into the side of a mountain.

(234) **Thermal protection of combustion chambers for powder rockets.** P. DERIAZ. *Rech. Aéro.* (37), 29–32 (*Jan.-Feb.*, 1954). General review of refractory coatings and their application. Because of the short burning period suitably chosen coatings will enable the metal temperature to be kept at an acceptable level during the burning time.

(235) **Determining the maximum performance of rocket motors by static firing tests.** R. H. REICHEL. *Interavia*, **9**, 172–174 (*March*, 1954). Method of determining mixture ratio for maximum performance by automatically maintaining a constant chamber pressure over a range of mixture ratios.

(236) **Instrumentation of rockets and missiles.** *Insts. Autom.*, **27**, 606–607 (*April*, 1954). Description of instrumentation at the Experimental Rocket Engine Test Station in the Mojave Desert.

ROCKET PROPELLANTS

(237) **The influence of the geometric form of propellants on their consumption.** G. SEITZ. *Sprengtechnik*, 221–227 (1952), 15–18 (1953). (*In German.*) Mathematical survey of solid propellant grain forms.

(238) **Rocket Propellants.** D. SMOLÉNSKI. *Wiadómsci Chem.*, **7**, 58–86 (1953). (*In Polish.*) Reviews four propellant combinations and deals with hydrazine hydrate/hydrogen peroxide system in detail.

(239) **Theory of ignition considered as a thermal reaction.** B. L. HICKS. *J. Chem. Phys.*, **22**, 414–429 (*March*, 1954). Theoretical determination of ignition times for a solid propellant based on a purely thermal phenomenon (i.e. no diffusion) for various conditions of external heating and initial temperature.

ROCKET PROPULSION

(240) **The propulsive efficiency of a rocket.** E. MATTIOLI. *Aerotecnica*, **33**, 270–274 (*Aug.*, 1953). (*In Italian.*) New definition for propulsive efficiency.

(241) **Aerojet plays major role in rockets.** W. J. COUGHLIN. *Aviation Wk.*, **60** (7), 38–39, 41–42, 46 (*Feb.* 1954.) Review of Aerojet-General's activities which cover research and production of solid and liquid rocket propellant units.

REVIEWS

"Our Moon"

(By Dr. H. P. Wilkins, F.R.A.S. Published by Frederick Muller, Ltd., London. 1954. 12s. 6d. 180 pages with 5 plates, 20 drawings and charts.)

This splendid little book should be read by all who are interested in the Moon, not only as the Earth's satellite, whose surface appearance and features present so many unsolved problems, but also as a possible site for human habitation and activity in the future. The illustrations include copies of some fine photographs from Pic-du-Midi Observatory, a full-Moon photograph by E. A. Whitaker, Royal Observatory, Greenwich, and many fine drawings by the author.

Dr. H. P. Wilkins is, of course, a well-known selenographer, whose 300-in. map of the Moon is the largest and most detailed in existence. As Director of the Lunar Section of the British Astronomical Association, he has done more than any other expert to encourage observation of the Moon by amateur astronomers. *Our Moon* is a popular book, but contains up-to-date information, including the results of recent work by the author and Mr. P. A. Moore with the 33-in. refractor of the Meudon Observatory.

After three short introductory chapters on the history of lunar observation and the motion of the Moon, Dr. Wilkins presents the reader with a view of the Moon through a giant telescope. In six chapters, the author gives an exciting description of the remarkable formations visible along the shadow terminator at various phases. Apart from this telescopic spectacle, the student learns interesting facts about many of the features examined.

In chapter 10 we are transported to the Moon's surface, and experience, during the long day, some of the changes which we have already observed through the large telescope. Chapters 11, 12, 13 and 14 are concerned with changes and life on the Moon, the other side of the Moon, the crust and interior of the Moon, and mysterious happenings on the Moon. In this part of the book the reader is introduced to some of the very interesting and controversial aspects of lunar study, and it is only fair to point out that there will be the usual differences of opinion among lunarians on some of the topics discussed here by the author. In chapter 14, and elsewhere, Dr. Wilkins implies that a "lunar dome" is similar in appearance to a "bowler hat," which suggests a steep-sided curved mound. Telescopic observation of these interesting features tends to contradict this description, giving the impression of very low mounds, which show little or no shadow when close to the terminator.

In chapter 15 Dr. Wilkins considers the various effects of the Moon on terrestial affairs, and finally in chapter 16, he describes space flight to our satellite and the establishment of a lunar base.

Our Moon has four useful appendices, giving names and descriptions of the most important formations, a provisional chart of the other side, Latin names of the plains and hints on lunar observation.

As stated by Dr. J. G. Porter in his foreword, the author's life-long study of the Moon makes him particularly well fitted to write this book. His fascinating descriptions of lunar scenery should encourage amateur observers "to see for themselves," and, as there is so much more to be learned about the Moon before the first landings are made, perhaps some who read the book may wish to assist in the work of the Lunar Section of the British Astronomical Association.

K. W. ABINERI.

Flying Saucers on the Moon

(By H. T. Wilkins. Peter Owen, Ltd., London, 1954. 329 pp. 16s.).

A scientific journal is not the proper place to review this book, but it must be mentioned here in order to point out that its author, Mr. H. T. Wilkins, has no connection whatever with Dr. H. P. Wilkins, the eminent astronomer—even though he has the same name and premier initial, and lives in the same town (Bexleyheath). Any confusion between the two would be most unfortunate, since Mr. H. T. Wilkins believes that the Earth is being watched by flying saucers of all shapes, sizes and varieties; that some of them are hostile; that a bridge in Oregon, U.S.A., was probably destroyed by a cosmical death-ray (though just why is not clear); that the Moon does not rotate upon its axis; that the spectroscope shows no trace of an atmosphere round Venus; that the temperature of space is near absolute zero—and so on. These and similar views are put forward at great length. Unlike earlier books on the same theme, it does not even make entertaining reading; it adds nothing of interest to the Leslie-Adamski *Flying Saucers Have Landed*, and the kindest thing one can say about it is that it is tedious.

Strangely enough, Mr. Wilkins makes only one offhand reference to Mr. Adamski, in whom he has obviously little faith. Can there be a party split among the Flying Saucerers? However, no-one has yet written an eye-witness account of a conducted tour of Venus; there is still time for someone else to burst into print and become the first in this particular field!

P. MOORE.

CORRESPONDENCE

Space Travel

SIR,

In his review of *Space Travel* (by K. W. Gatland and A. M. Kunesch), Mr. Allen raises an interesting possibility. He suggests that a spaceship taking off from the Moon may be destroyed by the debris thrown up into a closed orbit (passing over the landing site), by its own jet on landing.

This could never happen. First of all, even if any of the debris did get into closed orbits these would not pass over the spaceship; for the rotation of the Moon carries the ship away from the "focal point" of the landing.

It would be quite safe, however, to land at the poles too, for although the ship would not then be moved away from the focus, there could not be any debris orbiting above it anyway. All the particles projected from the surface in elliptical orbits must intersect the surface again before completing even a single circuit of their orbits.

We may note that this second intersection takes place before the particles reach their point of projection, so that there is no chance of the ship being destroyed on the ground either, some 100 minutes after its landing.

C. A. Cross.

Northwich, Cheshire.

Flying Saucers

Sir,

In his review of the book *Flying Saucers Have Landed* (*J.B.I.S.*, **13**, 119–112), Mr. Clarke does much to demonstrate the inaccuracy of certain technical points contained therein, but he has not pointed out three rather startling obvious mistakes or misquotations in the second chapter. This particular section lists some two hundred so-called sightings of "Flying Saucers" from the seventeenth century up to the present date. To the layman the mistakes are not at all clear as being entirely opposed to their true character, as can be clearly shown:—

(*a*) Page 27, line 19. Leslie claims that Richard Carrington, the renowned solar observer of last century, observed two moving luminous bodies on the Sun's face on September 1, 1859. It is true Carrington did make an observation of a strange phenomenon of the Sun on this date, but what Leslie does not mention is the fact that the observation was of a solar flare in white light—definitely not a "saucer"—see *M.N.R.A.S.*, XX, pp, 13–15, 1859, for Carrington's own description.

(*b*) Page 29, line 32. Here we find quite a renowned series of searches and reports mistakenly taken for "saucers." Leslie claims that Swift and Lewis observed bright bodies near the Sun at the time of the solar eclipse of July 29, 1878, but here again he omits to mention that these astronomers were on the lookout for the mythical planet Vulcan. It was generally assumed that what these observers actually did see were faint stars, haste and excitement blinding their capabilities for observation.

Needless to state Einstein disposed of Vulcan with the formulation of his Theory of Relativity. *See* Clerke, *A Popular History of Astronomy During the Nineteenth Century*, 1908, pp. 249–250.

(*c*) Page 45, line 13. In this particular instance an amusing episode and a demonstration of lack of care is presented to us. Leslie states that Lieutenant Herschel, when stationed in India, observed a curious swarm of dark objects crossing the solar face on two dates, October 17 and 18 (the year not being given). A search has revealed that Herschel did observe these features, but at the same time as his observations were reported, the explanation was also given—actually a swarm of locusts passing over the Sun's face! See *M.N.R.A.S.*, XXX, 5, pp. 135–138, *Dark Bodies Crossing the Sun*, March, 1870.

The inclusion of these observations alone in the book in question cast doubts on the report so lucidly presented to the reading public. The absence of proper

references and lack of care with the Herschel affair, lead me to assume that other reported historical sightings may easily be explained, in which case the whole fabric of part one of *Flying Saucers have Landed* crumbles to ashes, which in turn affects the main object of the book.

R. M. BAUM.

Boughton.

Some Notes on the Reactions of Aircraft Pilots to Zero Gravity

SIR,

It is possible by careful manipulation of the controls of some types of aircraft to suspend a subject several inches above his seat under conditions of approximately zero gravity for periods of up to 20 seconds.

I have been able to assess the reactions of some 20 subjects (all qualified pilots of varying experience) and these are summarized below.

(*a*) An immediate feeling of insecurity resulted in a reflex action which caused the subject to clutch at something—usually the seat or sides of the cockpit.

(*b*) This was quickly followed by a sense of relief and relaxation.

(*c*) The ability to perform a simple mechanical action like setting a figure on an instrument dial by turning a knob was unimpaired, although this varied greatly with the subject's experience as a pilot and his trust in the operator of the aircraft.

(*d*) The ability to do mental arithmetic varied greatly and to no discernible pattern.

(*e*) Any loose articles like gloves, maps, etc., which "floated," tended to distract the subject from whatever he was asked to do.

(*f*) At first most subjects tended to allow their arms to float up in front of them unless they were required to do something.

(*g*) No subject complained of nausea or felt in any way distressed. Most of them enjoyed the experience and were willing to repeat it.

One point of great practical importance. In any future rocket ship which is expected to experience zero gravity, both the crew and any passengers will have to wipe their feet most carefully before entering! The amount of dust, mud and swarf, etc., which normally lies concealed under conditions of normal gravity, soon proves to be a considerable nuisance when it forms part of the vehicle's atmosphere under zero gravity.

L. A. COE.

Tidworth, Hants.

[*F./L. Coe, in a further letter, describes how the above manoeuvre was carried out by him on his own initiative in a Meteor Mark 7 jet trainer. By terminating a steep climb by rapidly closing the engine throttles, it was found possible to subject his "guinea-pig" passenger to the zero gravity effects summarised above. The technique used was similar to that described by Heinz Haber in his book "Man in Space," and probably the same as that employed by Major Charles Yeager. Major Yeager reported rather more unpleasant effects than those experienced by F./L. Coe's subjects, which may not have been entirely due to zero gravity.*—EDITOR.]

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